THURSDAY, DECEMBER 2, 1886

INDUSTRIAL EDUCATION IN AMERICA

Industrial and High Art Education in the United States. Part I. "Drawing in Public Schools." By J. Edwards Clarke, A.M. (Washington: Government Printing Office, 1885.)

CHANGES required in school training, in the substance as well as in the method of it, are now felt to be a vital question to the political economist and the law-maker, as well as to the moralist. While the old apprenticeship system was in its vigour, the youth was taught at school the three R's and whatever other branches of a liberal education his parents could afford, and for seven years after that technical instruction was given to him in all the branches of the trade he had chosen by his master, the best teacher that could be found in those days. But under the influence of machinery that system has completely collapsed, and the feeling is rising everywhere that something must be done at school to replace instruction given of old by the master. Theorists insist that nothing short of a technical school, where each trade is taught from beginning to end, will sufficiently replace the care and the interest of the latter, and they hold up the Russian Strogonoff school as an example of their being taught in this complete way and triumphantly compare its work with that of the best manufacturing countries. They urge that in a system of public education like that of the United States it is a serious fault that, while a classical or professional education is provided free for the youth who desires it, technical instruction is denied to a far larger body of mechanics who have as perfect a claim to the education they require. In Stockholm the experiment of every elementary school having a carpenter's and joiner's shop attached is being tried, but the impracticability of carrying on in every town schools where instruction in each art can be efficiently given to the labouring classes has left the teaching of theorists little else but theory, and a technical school giving instruction in the one or two principal trades of a district is all that can be looked for.

One item of education, however, has made its way in most European countries, as being a help to all technical work, encouraging observation and correctness, and enabling such observation to be registered and expressed. It is here asserted to be a qualification for nine-tenths of the occupations into which all labour is divided, and is welcomed by the most advanced supporters of technical schools as the first step. Reading, writing, arithmetic, and drawing are now to be the four fundamental studies. A knowledge of it is essential in many of the studies in the schools of science, and especially useful to all engaged in the profession of teaching. More doubtful assertions are that like other technical teaching it does not necessarily interfere with or hinder other work, and that it positively assists in learning to write; this latter having the authority of the London School Board, as well as that of an American writer quoted in this volume. The rise in value also in the labour-market of each mechanic who has the power to draw or even understand a drawing of a mechanical arrangement is often insisted upon; but when such an accomplishment has become common to all, and therefore gives its possessor no superiority, this is rather doubtful, though the raising of a whole class to the capacities of artists and engineers will very likely add to republican equality.

While England has for years encouraged the teaching of drawing, and, the year before last, made it a part of the education of all boys in elementary schools, in the United States a sense of its importance has been only slowly making its way. Recently, however, the Senate requested all information on the subject of industrial and high art education in the United States to be laid before it by the Education Bureau. This work was committed to Mr. J. Edwards Clarke, already the author of a Circular on the subject published in 1874, which excited so much interest and drew so much further information that it is reproduced at p. 487 of this volume, having now, the author claims, some little historical interest, the meagre list which it contains of art institutions in the country at that date contrasting with the changes already brought about. The Bureau had already decided to prepare a much more comprehensive work, which should combine a history of the earliest efforts of writers of all views in all parts of the United States and in England; an account of their failures and successes, and especially of the Massachusetts success; with information as to planning schools of high art and public art-museums; lists of art-publications and materials; extracts from foreign official reports as well as from other foreign material. This, even before the Senate's Commission enlarged its scope, was sufficient to make a tolerably voluminous work. But a source of disorder and much repetition has been a series of delays in its publication. It was complete for publication in 1877, and while in one article of that date criticising the few artistic buildings which New York could show in 1875, it rejoices in a later one at the improvement there in 1883, and the artistic taste displayed by its architects; it was ready again in 1880; corrected again for 1882, and statistical tables down to 1881–82 printed, which again it is promised shall be supplemented by tables reaching down to June 30, 1885, at the end of the fourth volume to which this work is to reach. It was printed in 1885, and inserts publications of that year, yet quotes from an "unpublished" report of the National Educational Association held in 1884; and it is still only promised to the public at this year's end. Since this one volume extends to 1100 pages of, for the most part, small-printed matter, the whole work may be looked upon as an encyclopædia of information bearing upon the drawing question, of value chiefly to two classes of men, viz. school teachers, who will find nothing wanting, and earnest advancers of art education. For unless the general public in America be far different from our own they will not be *led* into the study of the subject by such a publication as this, and in its present form it must quite fail of the general effect upon them aspired to on p. xxx. The fourteen papers by the compiler with which the work opens would be appropriate for rousing attention if dispersed over the country in the most handy form; in their present position their inflated and impetuous style is inconsistent with the idea of exactness to be expected in this class of publication.

As late as 1876 the introduction of drawing into the

public schools was looked upon as a novel project in the United States; for while Mr. Clarke considers that England has spent "an enormous aggregate of money in the work" the Americans, so profuse in other educational expenditure, have been strangely apathetic in the matter. One explanation given is that during the Middle Ages the Church and the aristocracy were the great patrons of high art, and this bred an instinctive dislike to its pursuit in the minds of New England emigrants. But besides the delineation of Nature and of all her forms of beauty, the minister of cultivated wealth and luxury, there is another branch of drawing of the highest importance to nearly every mechanic in these days, viz. geometrical drawing, the foundation of all industrial art, leading up to the elaborate perspective of a complicated machine. Both branches are of course required in many manufactures. Which shall be pursued with most energy in any town must depend upon its staple trades; in some few businesses, as in watches and woven fabrics, the mechanical and the ornamental have about equal claims. The same idea, that drawing meant ornamental art alone, and that its chief results would be the sort of things that accomplished young ladies bring home after a few terms of learning drawing, established itself in the minds of the ratepayers. To meet this the general tone of quotations through this report is that "industrial drawing is of the most practical nature, and has nothing to do with pictures of old ruins, landscapes, &c." Yet elsewhere Mr. Clarke is most contemptuous towards any who wish to confine the drawing taught in any school to "that part of it directly related to industrial interests"; and the teaching of the self-willed Haydon, of whom he gives a long account as the victim of cruel and ignorant persecution of "aristocratic connoisseurs" but as an apostle of art to the common people, is just as confidently quoted with no qualification. Haydon's teaching is that the study of the nude human figure is the best qualification of an artist for any manufacturing business, and every one holding a different opinion is dismissed by Mr. Clarke with contempt. This necessity for high art teaching is a hard doctrine, and certainly discouraging to those who hope to qualify a majority of the working classes for artistic producers or intelligent machinists. Perhaps it only resolves itself into the explanation given on p. 482 by Mr. Sparkes, and supported also by the quotation from Mr. William Morris, that the greater includes the less, and that if an artist is well able to delineate the "subtle lines" of the human figure in a complex attitude, he is not likely to fail in working up a lily or a rose; and this is only in accordance with Mr. Stetson's teaching quoted on p. 649. Still a superiority of French over German art designs is attributed to the former making the human figure their first study and then proceeding to flowers and ornament, while the latter take what seems to us the more natural course of the reverse order.

In 1870 the State of Massachusetts after inviting various experts to express their opinions (here reported) decided that drawing should be taught in all its schools. The larger part of this bulky volume is directly or indirectly the history of the call of Mr. Walter Smith, head master of the School of Art at Leeds, who was recommended by Sir Henry Cole to be intrusted with the management of the whole matter. There are 120 closely-printed pages devoted to his work in Massachusetts as Art Director from 1871. Every part of the subject was under his guidance, and to impress upon the reader the amount of work entailed upon him an additional chapter is added to describe the unsatisfactory state of things in Boston before his arrival. The whole of his first report for 1872 is given, and long extracts from each yearly report on normal schools and every other department afterwards. Plans of instruction for evening classes which he superintended, as well as of teaching in school hours, are quoted in full. To advance his subject he took to the principal towns in the State a travelling museum of models and examples for study, many supplied from South Kensington. In one appendix are given copious extracts from an address delivered by him to the Pennsylvania Legislature in 1877 on behalf of the Museum and School of Industrial Art of that State; in another practical papers on drawing, chiefly by him, of value of course to managers who have just succeeded in introducing the teaching of drawing; three lectures delivered respectively to the teachers of the three grades of elementary, grammar, and high schools; followed by extracts from similar addresses delivered, after his connection with Massachusetts had ceased, at Montreal and Quebec.

The chief difficulty of course in setting such a work going was the scarcity of teachers, and this remained a difficulty up to the last. A paper accordingly by General Francis A. Walker, describing drawing as the foundation of all technical education, urges that the normal school should in truth precede, not follow, the elementary school. Another difficulty which an Association of Teachers found, and which showed the state of things at that time, was that there was so great a scarcity of art-books in the country that the Association set itself to encourage the reprinting, translation, and publication of such books.

On the whole, the energy inspired and the method introduced were so successful in Massachusetts that we are told that its history will form a lasting monument alike to the genius of Walter Smith and to the far-reaching foresight of the school authorities and State Legislature in 1872–73.

Appendix D is an account of the differences which rose between the Committee of Education in Massachusetts and Prof. W. Smith. The latter has now returned to England and taken the head mastership of the Art Department of the Technical College at Bradford. Great regrets are expressed at the, to them, untimely event of his resignation, and it is lamented that he should return from leading the industrial education of a continent to an English provincial college! The work now (1883) is reported as in too few hands, though still progressing from the impetus it had received.

No other States have gone into art education with the energy which Massachusetts displayed in 1872. Two others only, New York and Maine, have required that it shall be taught in all schools. In the latter it is urged as the more important, because every natural feature of the country points it out as the seat of manufactures and not of agriculture. But neither Maine nor New York has provided a normal school for the training of teachers. In various other States, however, individual cities have adopted drawing and made it a regular part of the course.

Syracuse, in the State of New York, can boast a priority in this good work even over Boston.

Though speaking everywhere most bitterly of England,—an Americanism so out of date now that happily it is more comical than irritating, especially when he goes so far as to call the great works on political economy which have made their way over the whole civilised world "emissaries of English policy which she has succeeded in introducing,"—the writer everywhere holds up England as an example in art education. The whole of the work is credited to Sir Henry Cole and South Kensington, although there were twenty Government-supported Schools of Design in England in 1847. Still the writer cannot resist the sneer that there would have been no art-teaching in England if a Royal Prince had not urged it! But many times over he relates how visitors were struck with the clumsy inartistic style of all English art-work at the Exhibition of 1851 compared with that of many foreign nations, and the good result of an energetic and most successful effort by the nation to remedy it is constantly urged as appearing at the Philadelphia Exposition of 1876. There the Americans found themselves as far behind England as England had been behind other European countries in 1851, through the inartistic ignorance of their manufacturing classes. Many practical lessons and suggestions were there supplied to them, and much of this volume is a record of their influence. Appendix E gives a lengthy paper by Mr. Stetson reviewing the work exhibited there by all the various foreign nations and by each of the American towns, and it records the influence of this Exhibition upon industrial art. We should like to have heard something, however, of the result of the New Orleans Exhibition, no report of which has reached us, although so much was promised.

While anxious by making drawing general to "utilise all the pleasure which a slate and pencil give a child," Mr. Clarke's unqualified love of liberty makes him object to infringing on even a child's freedom, and actually trusts to the extra interest that many gutter children would take in gaining technical skill to render compulsion unnecessary. He urges with good reason that nowhere would artistic skill be so well rewarded as in the United States during its present rapid rise in wealth as well as in population, and that skilled art labour is far more valuable than the labour bestowed upon plainer, rougher work. He does not however, in his promises held forth to all alike who learn to draw, appear to realise the division of labour between the designer and the numerous mechanics who carry out the artist's ideas on the machine, but seems to look upon all artistic work as carried out single-handed from the design to the article ready for sale. No doubt it is here, as General Walker (already quoted) remarks, that there are boys that have genius in their eyes and fingers instead of a memory and quickness at book-training, who would profit by artistic training. Many such specially gifted artists have already made their mark in America both in architecture and in engraving; the standard of magazine illustrations having been raised even in England by competition with American productions. A larger class whose labour art-education makes valuable are women who are anxious to secure to themselves an independence. They are the principal teachers of drawing in all its branches, and find an excellent outlet for talent. Many artistic trades are also now carried on successfully by them; an account is especially given in Appendix E of the wood-carving taught at a women's school in Cincinnati introduced there by an English workman of the name of Fry. Ladies there, among others, make it a pursuit with great success.

Besides other papers incidentally referred to in our above remarks, various writings of considerable length and of dates from 1845 to 1884 are given in Appendixes A, C, and E, all urging the importance of art education, and instructing those engaged in teaching it.

Appendix F consists of 70 closely-printed pages giving an account of South Kensington, its officials, history, Art Training School, Museum, Art Library, art examples, books, and casts; with the reports for 1882 and 1884, and copious extracts from the Art Directory to show in detail the conditions and regulations under which "aid" is granted in England. Some of the quotations in this appendix are taken from the Directory of 1885. Mr. Clarke assures his countrymen that "in its appointments, and influence on art industrial education, South Kensington Museum stands without a rival. It is a wonderful centre of educational energy." "Other countries, even France, are giving it their official indorsement by modifying their art industrial instruction as rapidly as may be, and bringing it more into harmony with that of the English."

The final Appendix, H, claims to be a fitting end to this volume, and a foreshadowing of the contents of the future volumes. It is Lord Reay's address to the International Educational Conference at the Health Exhibition in 1884.

The printing of this volume is far from so correct as might be expected in a Government publication on Education.

W. ODELL

OUR BOOK SHELF

American Journal of Mathematics. Vol. IX. No. 1. (Baltimore, October 1886.)

WE are glad to note that the successive parts now appear with praiseworthy regularity, and the arrival of our number can be predicted to a very close order of approximation. The volume opens with a continuation of Prof. Sylvester's lectures at Oxford on "The Theory of Reciprocants." The story is resumed with the eleventh and proceeds to the close of the sixteenth lecture. For the cumbrous terminology "projective reciprocants" or "differential invariants" the lecturer now suggests "principiants." From Lecture xiv. the abstract is devoted to the theory of pure and projective reciprocants, or rather principiants, and here we are introduced to the existence and properties of the protomorphs of invariants and reciprocants with which Mr. L. J. Rogers, one of the lecturer's audience, has made us elsewhere familiar. For an account of Dr. Story's new method in analytic geometry, we refer our readers to the author's own description. Dr. F. N Cole gives a full review in Klein's Ikosaeder of what that eminent mathematician has done in his "Vorlesungen über das Ikosaeder und die Auflösung der Gleichungen vom fünften Grade" (1884), and in his "Vergleichende Betrachtungen über neuere geometrische Forschungen" (1872). In Prof. Greenhill's paper on wave-motion in hydrodynamics the writer states that "one of the most important applications of the theory of hydrodynamics is to the question of the motion of waves under gravity and other causes," and his object is "to collect together the chief results hitherto obtained, and to give also a general connected account of the mathematical theory, at the same time attempting to develop it in some directions."

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Longitudes in Brazil

LE numéro du 18 novembre de NATURE publie un article du professeur Young sur les progrès de l'astronomie depuis dix ans, dans lequel il est dit que les observations de longitude télégraphiques des officiers américains ont corrigé une erreur de 8·54s. sur Lisbonne, et une bien plus étonnante encore de 35s. sur Rio.

Il y a là une grosse erreur inexplicable de la part du professeur Young, contre laquelle je dois protester comme auteur des cartes hydrographiques du Brésil encore employés aujourd'hui, et auteur de toutes les déterminations géographiques relatives et absolues faites douze ou quinze ans avant la mission américaine de MM. Green et Davis pour les longitudes télégraphiques entre le Brésil et l'Europe.

Sur les mille lieues de côte du Brésil la mission américaine a déterminé six longitudes entre le Para et Buenos Ayres. Voici la comparaison des résultats obtenus par MM. Davis et Green, à l'aide du télégraphe, et par moi, à l'aide de chronomètres et d'observations astronomiques directes. Les observations américaines sont publiées dans le numéro 59 (1880, je crois) "Hydrographic Notice," et les miennes dans les "Annales hydrographiques, 1866."

	Para			Pernambouco			Bahia		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
Long. télégraphique.	3	23	20·94	2	28	48·6	2	43	29·6
Long. Mouchez ...	3	23	18·67	2	28	47·5	2	43	26·9
Erreur			– 2·27s.			– 1·1s.			– 2·7s.

	Rio			Montevideo			Buenos Ayres		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
Long. télégraphique.	3	2	2·3	3	54	9·9	4	2	49·9
Long. Mouchez ...	3	2	0·1	3	54	9·4	4	2	49·9
Erreur			– 2·2s.			– 0·5s.			0·0s.

Il résulte de ce tableau que la plus grande erreur que j'ai commise est – 2·7s. sur Bahia. A Rio l'erreur est de – 2·2s., et non de 35s. comme le prétend M. Young. Dans le Rio de la Plata l'erreur a été trouvée nulle.

Je ne crois pas qu'aucune étendue de côte de mille lieues eut jamais présenté moins d'erreur absolue ou relative que la côte du Brésil après la publication de mes cartes et de mes observations.

Quant à l'erreur sur Lisbonne je l'avais signalée depuis plus de trente ans, elle était connue.

Je vous serais très obligé de vouloir bien publier au moins le tableau comparatif des longitudes que j'ai l'honneur de vous envoyer aujourd'hui, pour protester contre l'erreur qui m'est indirectement imputée.

Veuillez agréer l'assurance de ma parfaite considération.

E. MOUCHEZ

Cooke's "Chemical Physics"

I AM told that I have been the object of severe strictures in your journal for republishing my old "Chemical Physics" as if it were a new book. It is a sufficient answer to say that the book was stereotyped when first issued in 1860, and that there has never been any pretence on my part that it has been revised since. I find, on inquiry, that the American publishers have made, since the first edition, three reprints from the plates, and have called these reprints second, third, and fourth editions, changing, with each issue, the date on the title-page; a usage which I regard myself as reprehensible, but which must be sanctioned by the trade since it is so universally followed. All this time, however, the date accompanying my signature after the preface, and the date of the copyright, have remained unaltered. I had supposed the book entirely out of print; and the last reprint of a very few copies to meet a small demand still existing, chiefly in England, was made entirely without my knowledge or consent. On its very face the whole aspect of the book is antiquated; but in it there was brought together certain positive knowledge in connection with the weighing and measuring of aëriform matter, derived chiefly from the classical researches of Regnault, which is still of great importance and not readily found elsewhere; and this is, unquestionably, the reason of the continued demand for a compilation made more than twenty-five years ago. I have, until within a few years, had the expectation of revising the book and presenting the old facts in their new dress, but the failure of my sight has obliged me to give up the plan, and younger men must do the work.

JOSIAH PARSONS COOKE

Cambridge, U.S.A., November 16

Note on Mr. Budden's Proof that only One Parallel can be drawn from a Given Point to a Given Straight Line

MR. BUDDEN's paper in the last number of NATURE (p. 92) is full of inaccuracies of a more or less serious character. Without pointing out these, I wish to show that the essential idea which underlies his reasoning is altogether wrong, as it is based on the "infinite," which he introduces in the most innocent manner by letting his figure grow without limit, and about which he then calmly reasons as if he still dealt with a finite figure. If we let a quantity "increase without limit," we get a quantity which has increased beyond our comprehension, and no one in his senses will wittingly and seriously draw conclusions from what he does not comprehend. Here we might stop, were it not that the constant use in modern mathematics of the infinite (both the small and the great) has made us so familiar with it that an attempt to base an elementary proof on it might seem to many a very natural thing.

In algebra, the infinite number is shown to have one property which we can comprehend, viz. that its reciprocal is zero; and with this property alone we work safely.

In modern geometry, on the other hand, the infinite is used as a kind of shorthand, which enables us to make long statements short, and, at the same time, general. Taking the axiom about parallels for granted, it is shown that all points at an infinite distance in a line may be taken to be one point as far as constructions at a finite distance are concerned. For all lines joining a fixed point, P, to any point at infinity in a line may be taken as parallel to this line, and therefore as coincident. To express this more shortly, it is said that the whole indefinite and infinite part of a line which is out of the reach of our comprehension plays for us only the part of a single point, and accordingly it is called a "point," viz. *the point at infinity* of the line. Similarly it is shown that all points in a plane which are at an infinite distance may be considered as lying in one line, which is then spoken of as *the line at infinity* in the plane, and which is freely and safely used in deducing theorems and solving problems.

If, then, a line in a plane be moved to infinity, making always a given angle with a fixed line, it will ultimately become coincident with—which here means indistinguishable from the line at infinity. The latter then makes with the fixed line a given angle. But this angle may be anything. Hence the "line at infinity" makes any angle we like with any given finite line; in other words, it makes no definite angle at all with it.

It follows, if we take a property of a figure which depends upon the magnitude of an angle, that this property will not necessarily any longer hold if one of the limits of the angle be moved to an infinite distance; for then this angle has not any longer a definite magnitude. To base any reasoning on that property after the figure has been indefinitely increased must therefore necessarily be fallacious. But this is exactly what Mr. Budden does. His proof is based on the implied assumption that if a figure in a plane be increased indefinitely, we can still reason upon it as if it were finite. He may take this as an *axiom*, but then he has *replaced* Euclid's axiom by another, and has not *proved* it; and the question would arise, Which form of the axiom is preferable? I prefer Euclid's.

O. HENRICI

Lunar Glaciation

I TRUST you will allow me a small space to explain regarding this theory of lunar glaciation, referred to by Mr. Darwin in NATURE (vol. xxxiv. p. 264).

First, I must thank him for the remarks made, and say that I certainly was not aware that Capt. Ericsson had been at work in the same direction some ten years or more before me.

I laid the theory before the late Prebendary Webb a few years ago, and some selections from it were published in the *Journal* of the Liverpool Astronomical Society, and, being necessarily incomplete, the extracts were not very intelligible. I have never attempted the settlement of the lunar surface temperature, which is quite beyond me, leaving the same in the hands of Prof. Langley, and have confined myself to the solution of the peculiar and unearthly surfacing we see. This I find best explained by glaciation, under conditions of intense cold, say $-60°$ or $80°$ C., and absence of all gaseous atmosphere.

I quite indorse Capt. Ericsson's conclusions as to the extreme unlikelihood of such a small globe being finally surfaced by igneous agencies, after it had seas of water, atmosphere, and probably *polar caps*.

Neison, in his "Moon," page 41, line 7, distinctly implies that this took place, *i.e.* "that this high temperature could only arise after the practical disappearance of bodies of water from the lunar surface," the rise in lunar temperature being due to solar heat.

I cannot follow Neison in this, and, on the contrary, believe that the temperature has steadily, if slowly, declined, from a period when there was erosion, with air and water. Polar caps then formed, as on our earth and Mars, and extended as the temperature fell, until at last the entire globe was cased in ice, the last portions to glaciate being what we call the equatorial seas.

Like Capt. Ericsson, I look on the craters and walled plains as having been lagoons of water, left here and there as glaciation extended, at places of greater depth, or more likely as submarine volcanic vents, for we see their sites as craterlets and cones after final glaciation.

The aqueous vapour given off from these lagoons would form a local dome-shaped atmosphere that would retard explosive ebullition, and on its reaching the outer limit of critical temperature, would condense and fall as snow; what fell beyond the lagoon margin would pile to form the ring, and the lagoon surface or flow be gradually lowered by its removal.

But I cannot follow Capt. Ericsson in supposing that the water had a centrifugal motion, and acted as a gigantic carving-tool, that sculptured the enormous terraces in Tycho, Theophilus, &c. On the contrary, I look on it as a quiet process, and that all the circular forms, from small craterlets to even such forms as Mare Crisium or Imbrium, with its huge maritime ranges, are due to one cause. The series is complete.

I quite agree with Mr. Darwin that a layer of water vapour would exist (and be visible) over the ice on the moon if only the temperature be high enough; but, at very low temperatures, ice practically does not vaporise even *in vacuo* (see Ganot's "Physics"). Aqueous vapour not being seen, I conclude the temperature is below (say) $-80°$ C. But the most potent argument in favour of my theory is that it reasonably and consistently explains *all* the peculiar features of lunar surfacing, *i.e.* :—

The absence of distinct Polar caps;
The absence of water and aqueous vapour (now);
The absence of distinct colour in details;
The brightness of all raised, rugged surfaces, mountains, cliffs, peaks;
The relative darkness of levels whereon meteoric dust can lie;
The extraordinary circularity of forms, large and small, incomplete, or overlapped;
The cones, whether central or isolated;
The clefts or rills, also strings of craterlets;
The maritime zones, ridges, and banks;
The haze or cloud, and nimbus or rayed brightness;
The dark points seen by Dr. Klein;
Lastly, if not least, the long bright rays.

I do not think I overstate the case when I say that selenographers will find these features consistently solved by the one hypothesis, and no enigmas left.

I cannot ask for space to go into details here, but will forward a short synopsis of the leading features, in case they may be required, arranging them as nearly as may be as in the preceding list. S. E. PEAL

Sibsagar, Assam, October 13

The Astronomical Theory of the Great Ice Age

THE lecture and the letter of Sir Robert Ball, however lucid, do not appear to carry this question further than where Dr. Croll left it. It is easy to understand that when the shape of the earth's orbit was different, winter days might be colder and summer days hotter than now. What the theory at present wants is an exposition of the successive series of effects by which this state of climates would transform the Emerald Isle into a mere Greenland. It is scarcely an explanation to say that "vast fluctuations like these must correspond to vast climatic changes of the kind postulated." We desire to be shown that they will correspond, and that the correspondence will be of the kind required. Taking Sir Robert Ball's own illustration, I am quite ready to admit that his horse alternately starved and crammed will not run a dead heat with one uniformly fed; but in default of experience I should not feel certain that his animal would die of accumulated fat.

We know that there have been past periods of heat-supply more uniform than at present, and periods of wider fluctuation. We see also in geological records ages of vast snow accumulation and ages of rich vegetation near the Pole. We need a demonstration that such wider fluctuations do tend to the one and not to the other; towards snow-accumulation and not towards snow-dissipation. Attempts in this direction have been made, but much seems needed yet. E. HILL

St. John's College, Cambridge, November 23

Meteor

THE large meteor described in NATURE by Mr. P. L. Sclater, was observed here as follows:—

Nov. 17, 7h. 18m.—Fireball many times brighter than Venus. Path from $32\frac{1}{2}° + 45°$ to $158° + 55°$. Motion very slow, duration 7 seconds. Train, but no enduring streak. The fireball, as it gradually descended to the northern horizon, varied greatly in brilliancy, and gave a series of flashes lighting up the sky with great effect. I have occasionally seen larger fireballs, but never observed one more satisfactorily. This meteor was observed at Handsworth, Birmingham; at Crawshaw Booth, Lancashire; and at many other parts of the country. Its unusual brightness seems to have attracted wide notice.

Fireballs from Taurus are often seen at about this epoch; but that of November 17 appears to have belonged to a radiant-point in Aries. W. F. DENNING

Bristol

Freshwater Diatoms in the Bagshot Beds

WILL you kindly favour me with space to ask any of your numerous readers, who may be specially interested, if they can furnish me with any references to published records of fresh-water Diatoms being observed in the carbonaceous earthy sands of the Middle and Lower Bagshot Beds of the London Basin? In conjunction with one of my pupils, I have lately subjected many of these green and dark-grey sands and earths to microscopic examination; and our labours have been rewarded by the discovery of a rather extensive unicellular flora, particulars of which will be shortly laid before the Geological Society. Meanwhile, I shall be happy to have the co-operation of other workers in the same field. A. IRVING

Wellington College, Berks, November 28

THE MATHEMATICAL TRIPOS[1]

I.

IT is with the greatest pleasure that I avail myself this evening of the already well-established custom which permits one of our members, once in two years, to address to his colleagues a few general remarks connected with the science that forms our common bond of union. It is not often that a mathematician has an opportunity of laying before his fellow-workers, by word of mouth, any views of his except such as relate to the actual mathematical investigations upon which he is engaged, which, from their very nature, can appeal directly only to the few who have laboured in the same field; and I feel it to be a high privilege to be permitted, in this room, and surrounded by familiar faces, to give expression to my thoughts and hopes upon subjects that are of common interest to us all as mathematicians.

[1] Address delivered before the London Mathematical Society by the President, Mr. J. W. L. Glaisher, M.A., F.R.S., on vacating the chai November 11, 1886.

I have not ventured to attempt any remarks upon the wide region of pure mathematics, or even upon the progress of such portions of it as have attracted the greatest share of interest among ourselves. I have felt that, as one who has resided and lectured in Cambridge for the past fifteen years, the most appropriate subjects for my address would be those upon which my residence in the University during an eventful period, or my experience as a lecturer, might to some extent qualify me to speak. Still, even when so restricted, I have found it no easy matter to decide upon the subjects to which I was most desirous of drawing your attention to-night.

I should like to have spoken at length upon the theory of elliptic functions. For fourteen years I have lectured regularly, each year, upon this subject, and no lectures of mine have been of so much interest to me. I belie e that the time is rapidly approaching when the elementary portions of the theory will be regarded as necessarily forming part of the common course of reading of all students of mathematics, so that a familiarity with sn's, cn's, dn's, and their properties will become as essential as the differential calculus to the mathematical equipment of every person who has made mathematics one of his subjects of study.

Quite apart from its far-reaching influence in all branches of pure mathematics and its widespread applications in mathematical physics, there are special reasons which make the theory of elliptic functions a subject of peculiar interest in a course of mathematical studies, and one to which it is important that the student should be introduced as early as possible in his career, whether he be reading mathematics for its own sake, or for the sake of its applications, or for its advantages as a mental training. It is the first mathematical "theory" that he meets with in his reading—meaning by a "theory" a body of theorems and properties of functions so related to each other that the student cannot fail to see from the equations themselves that they form a consistent and remarkable system of facts, worthy of study on their own account, irrespective of any applications of which they may be susceptible. It is true that trigonometry, if regarded as the theory of singly periodic functions, is a theory in this sense, but it is reached by the student at too early a stage for him to be enabled to appreciate the nature and importance of facts that are expressed in the mathematical language of formulæ, and even if it were not so, the manner in which the subject is treated in text-books (the functions being derived from the circle and applied to the solution of triangles, &c., before they are considered analytically) makes it difficult to separate the mathematical theory from its various applications. In analytical geometry, which the student next meets with in his reading, a method of representing curves by equations is explained, and applied to the investigation and proof of properties of conics. In his next subject, differential calculus, he is introduced to new conceptions and processes of the very highest importance and the most fundamental character, and is taught to apply them to the investigation of maxima and minima, tangents and asymptotes to curves, envelopes, &c. Then come the elements of the integral calculus and of differential equations: the former consisting of a few chapters giving methods of integrating various classes of functions, followed by applications to curves and surfaces; and the latter of rules and methods for treating such equations as admit of finite solution.

Not one of these subjects, in the form in which they are necessarily presented to students, is an end in itself or exists for itself: they consist of ideas, methods, processes, and rules, which the student is taught to apply and to understand; they contain the conceptions with which he has to make himself as familiar as with the commonest facts of life, the tools which he is to have ever ready to his hand for use. And in the course of acquiring this knowledge he is made acquainted with numerous connected series of propositions—such as the properties of conics—besides various important results of more purely analytical interest. But all of these developments are presented to him in a form which throws no light upon the manner in which they were originally discovered, and, though the propositions are made to follow one another in clear logical order, the student cannot but be sensible that he is travelling, not along a natural highway, but upon a well-worn road, artificially constructed for his convenience. It is not till he reaches the subject of elliptic functions that he has the opportunity of seeing how, by means of the principles and processes that he has learned, a theory can be developed in which one result leads on of itself to another, in which every system of formulæ suggests ideas and inquiries about which the mind is eager to satisfy itself, and opens to the view fresh formulæ connected by unsuspected relations with others already obtained, so that he cannot resist the feeling that the subject is taking its own course, and that he is merely a bewildered spectator, delighted with the results which unfold themselves before him. He feels that the formulæ are, as it were, developing the subject of themselves, and that his part is passive: it is for him to follow where the formulæ point the way, and be amazed by the new wonders to which they lead him.

It may be that in using this language I am expressing the feelings of a mathematician, rather than those of a student on reading the elements of the subject for the first time; still I am convinced that the attributes I have just referred to are those which distinguish a genuine mathematical theory from a mere collection of useful principles and facts, and that no one can have studied elliptic functions without realising that mathematics is not only a weapon of research but a real living language—a language that can reveal wonderful and mysterious worlds of truths, of which, without its help, the mind could have gained not the least conception. It seems to me, therefore, of the highest importance that the student should be introduced to a real mathematical theory at the earliest stage at which his knowledge will permit of his deriving from it the peculiar advantages which I have mentioned. Thus only can he obtain expanded views or a true understanding of the science he is studying. Higher algebra and theory of numbers afford other conspicuous examples of the perfection that a pure mathematical theory can exhibit, but they do not lie so directly in the line of a general mathematical course of studies. Regarded from this latter point of view, elliptic functions has the additional merit of being a subject whose importance is recognised, on account of its physical applications, even by those to whom the gift of duly appreciating the wonders of pure mathematics seems to have been partially denied.

I should have liked also to have spoken at some length upon another subject that is constantly in my thoughts: I mean the pressing need of text-books upon the higher branches of mathematics. Of text-books for use in schools we have an abundance, and each month produces a fresh supply; but it is only occasionally that we have to welcome a work intended for the use of the higher University student or the mathematician. Every one of us must sometimes have felt the want of an introductory treatise that would give the reader the fundamental propositions in some branch of mathematics which exists only in memoirs and papers scattered throughout the wilderness of *Journals* and *Transactions* of Societies. We can scarcely expect to have provided for us, in many high subjects, text-books so admirable and thorough as Dr. Salmons; still I cannot refrain from expressing the hope that in the future the number of advanced mathematical treatises may not be so infinitesimal compared with the number of memoirs as at present. I could mention several subjects that are almost at a standstill, because advance is impracticable for want of avenues by which new workers

can approach them. Of necessity the literature of mathematics must always be in the main a journal literature, for the audience addressed is small; but I cannot help feeling that the disproportion between the amount of exploration effected and the attempts made to render accessible the territories explored and conquered might be greater than it is. No one can realise more vividly than I do how vastly more difficult it is to write a book than a collection of memoirs, and how beset with anxieties, for any one who is at all fastidious, is the task of arranging the fundamental properties of any comparatively new subject in clear and logical form. The sustained struggle to attain clearness, exactitude, and thoroughness in the orderly development of a complicated and mutually-connected system of propositions wears out the worker more than thrice the same amount of labour devoted to new investigations with all the fascinating excitement of successes and failures, rewards and disappointments. In writing a memoir, the mathematician begins where he pleases, and confines himself to what has interested him and what he knows he has done well. In composing a book, the author has not only to marshal into order an array of theorems of various kinds, assigning to each its due place and importance, but he has—hardest task of all, perhaps—to confine his treatise within bounds, to keep it from growing to gigantic proportions as his increased study of the subject opens up to him fresh vistas. On the other hand, however, is to be considered the great service he can thus render to his favourite study: an introductory treatise on a subject not otherwise approachable by any direct route, even if it be not of the highest class, may have done far more for its advance than could have been effected by the most brilliant memoir. Time, care, and thought are essential for the preparation of any valuable treatise, and full references to the original memoirs should be always given; if these conditions have been fulfilled, the writer has deserved well of mathematical science.

I have not been able to forbear from making the few preceding remarks upon two subjects on which I have long felt strongly; but I pass now without further delay to the main subject of my address—the Mathematical Tripos. I have thought that, in view of the importance of this examination to our science, and the frequent changes that have taken place recently, this might be a subject of no ordinary interest to our members as well as to myself. Since 1872 change has succeeded change with great rapidity, and there are probably not many outside the mathematical portion of the resident body at Cambridge who are fully aware of the present mode of conducting the examination or of the further changes already sanctioned by the Senate and which take effect next June. It is, indeed, generally known that the list of wranglers, senior optimes, and junior optimes is published in June, at about the same time as many other Tripos lists, instead of by itself in January, and that the senior wrangler is displaced from his throne, and no longer owes his position to the results of the whole examination, so that he is not necessarily—even from an examination standpoint—the first mathematician of his year. So much only is generally known; and it has seemed to me that it might be of interest, considering the influence for good that it is hoped the examination in its new form will have upon the progress of mathematics, to give some account of the successive developments that have taken place in this time-honoured examination, and the causes and efforts that have led to them. The difficulties connected with the placing of all the mathematical candidates of the year in one order of merit, the extension or limitation of the subjects of examination, and various other questions connected with the Tripos, are matters that have been continually discussed and re-discussed in the light of fresh experience by those concerned with the mathematical course of studies at Cambridge, but I may, nevertheless, perhaps be permitted to-night very briefly to refer to some of the familiar arguments in the presence of a more extended audience of mathematicians.

It is convenient to preface the principal remarks I have to make by an outline of the history of the Tripos. In doing so, I must pass very lightly over its origin and early development, as anything approaching to a complete history of its origin and rise in the last century would amount almost to a history of the studies of the University.

At the beginning of the last century, besides certain merely formal disputations, the only exercises required from candidates for degrees were the keeping of acts and opponencies. Each candidate for honours in the course of his third year had to maintain publicly a thesis, the subject of which was chosen by himself, against three opponents, in the presence of one of the Moderators, who acted as umpire. The subjects selected were philosophical or mathematical; the discussion took place in Latin and in logical form. After hearing the discussions, the Proctors and Moderators prepared a final list of candidates qualified to receive degrees. This can scarcely be considered to have been an order of merit, for each of the Proctors and Moderators, and also the Vice-Chancellor, had the right to introduce the name of one candidate into the list whenever he pleased; still, except in the case of the recipients of these honorary degrees, it is probable that the list in the main fairly represented the merits of the candidates. It was divided into three classes, consisting of (1) the wranglers and senior optimes; (2) the senior optimes who had done fairly well but had not distinguished themselves; and (3) οἱ πολλοί, or the poll-men. The first class received their degrees on Ash Wednesday, taking seniority according to their order on the list, and the two other classes received their degrees later.

With regard to the origin of the Tripos, Mr. W. W. Rouse Ball, in his interesting sketch of its history,[1] writes:—

"The impressions gathered from these disputations in the schools were necessarily rather vague, and when they became the sole University exercise for a degree they hardly afforded a sufficient basis for an accurate arrangement of the men in order of merit. It was, I believe, to correct this fault that the Senate House examination was introduced, and I am inclined to think that it had its origin about the year 1730. At first it probably consisted only of a few *vivâ voce* questions addressed by the Proctors and Moderators in the week after the schools to those candidates about whose abilities and position some doubt was felt; but its advantages were so patent that within ten or twelve years it had become systematised into a regular examination to which all questionists were liable, although technically it was still regarded as only supplementary to the exercises in the schools. From the beginning it was conducted in English, and accurate lists were made of the order of merit of the candidates; two advantages to which, I think, its final and definite establishment must be largely attributed."

Mr. Ball divides the time during which the exercises in the schools and the Tripos were concurrent into five periods: (1) from 1730 to about 1750, during which time it was probably unauthorised and regarded as an experiment; (2) from 1750 to 1763, during which it was gradually establishing itself,—in the last year of this period it was officially decided that when a candidate's position in the class-list was doubtful the Senate House examination and not the disputation was to be taken as the final test; (3) from 1763 to 1779, during which definite rules were framed and laid down for conducting it; (4) from 1779 to 1827, during which it practically superseded the disputations; (5) from 1827 to 1841, the year in which the disputations were abolished.

The lists published in the Cambridge University Calendars begin with the year 1747, because in that year

[1] "The Origin and History of the Mathematical Tripos," Cambridge, 1880. (Reprinted from the *Cambridge Review*.)

the final lists were first printed and distributed, the names of those who had received honorary degrees being specially marked, so that by simply erasing them the true order of merit of the other candidates could be obtained. The division of the first class into wranglers and senior optimes was first made in 1753.

It was in the third of the above periods, that is, between 1763 and 1779, that the Senate House examination was gradually gaining ground upon the schools in determining a candidate's final place on the list. By means of their acts and opponencies the candidates were divided by the Moderators into eight classes, each class being arranged in alphabetical order; their subsequent position in the class was then determined by the Senate House examination. The first two classes comprised those who were expected to be wranglers, the next four included the other candidates for honours, and the last two consisted of poll-men only. The classes were examined separately and *vivâ voce*. During this period it became the custom to require written answers to the questions. The examiner gave out the questions to the class one by one, giving out a fresh question as soon as he saw that any one had finished the last. The problem papers, which were confined to the first two classes, were given to the candidates in writing, so that they had the whole paper before them at once.

It may be of interest to give a more detailed account of the exercises in the schools during this period, when both the exercises and the examination were in full operation and vigour. The Moderators, having received from the tutors of the Colleges a list of the students who were candidates for honours at the next examination, fixed a day in the Lent term on which each was to keep his act, and assigned to him three opponents. The Respondent, or "Act" as he was then called, selected three subjects which he proposed to maintain, and submitted them to the Moderator, who communicated them to his three opponents, designating them *opponentium primus*, *secundus*, or *tertius*. On the day fixed for the Act the respondent read his thesis in the schools in the presence of the Moderator. The first opponent then mounted the box opposite to that of the respondent and below that of the Moderator, and joined issue with him, opposing the thesis by eight arguments of syllogistic form. The respondent replied to each in turn, and when an argument had been disposed of, the Moderator called for the next in the words *Probes aliter*. When the disputation had continued long enough, the Moderator dismissed the opponent with such words as "*Bene disputasti*," or "*Optime disputasti*," or "*Optime quidem disputasti*," as the case might be. The second and third opponents (who had to oppose the thesis by five and three arguments respectively) entered the box successively, and after disputing were dismissed in the same manner, the whole performance lasting between one hour and two hours. The respondent himself was dismissed with some such phrase as "*Satis et optime quidem tuo officio functus es.*" Such compliments gave rise to the classification into senior and junior optimes. In general, "*Optime quidem*" was the highest praise expected even by future wranglers. The distinguished men of the year appeared eight times in the schools, twice as Respondents and twice in each grade of opponency.[1]

[1] Wordsworth, *Scholæ Academicæ* (1877), p. 37. A specimen of an argument, expressed in scholastic form, on the question, "Recte statuit Paleius de Virtute," is given by Wordsworth on p. 39, and the full system of eight arguments (in a disputation of 1784) on the question, "Solis parallaxis ope Veneris intra solem conspiciendæ a methodo Halleii recte determinari potest," is reproduced in detail by Mr. Ball in the appendix to the sketch already referred to. In the latter part of the last century it seems to have been usual for two of the questions to relate to mathematics and the third to moral philosophy. Wordsworth mentions that in 1710-11 it needed all the influence of an enthusiastic Proctor and Moderator to induce a student to keep his act in mathematical questions, but that by the middle of the century the examination was so far crystallising into the *Mathematical* Tripos that a questionist was enabled by academical authority in 1750 to resist the demands of a Moderator to produce one metaphysical question, he having already distinguished himself in mathematical argument. In the early Cambridge University Calendars the three questions given as specimens are: (1) "Recte statuit Newtonus in septima sua sectione Libri primi"; (2) "Iridis primariæ et secundariæ Phenomena solvi possunt ex Principiis Opticis"; (3) "Recte statuit Lockius de Qualitatibus Corporum."

The final establishment of the Mathematical Tripos dates, as remarked by Mr. Ball, from 1779. By the regulations agreed to by the Senate in that year, the Moderators of the previous year were added to the regular staff of examiners, and the system of brackets was introduced. The examination lasted three days (the last of which was devoted to moral philosophy), and on the fourth day a class-list, called "the Brackets," was issued, in which those candidates who were nearly equal were bracketed together. One day was devoted to the "examination of the brackets," by the result of which the names in each bracket were placed in order of merit. There was also a power of challenging, by which a candidate who was dissatisfied with his bracket might challenge any other candidate he pleased to a fresh examination;[1] but it seldom happened that any one rose above or fell below his bracket. From 1779 onwards the examination slowly and surely grew in importance, and the exercises became of less account each year, till they were finally discontinued by the Moderators in 1839. Two years later they were formally abolished by the Senate.

The following account of the Senate House examination in 1802 is abridged from the Cambridge University Calendar of that year:—"On the Monday morning, a little before eight o'clock, the students, generally about a hundred, enter the Senate House, preceded by a Master of Arts, who on this occasion is styled the father of the College to which he belongs. On two pillars at the entrance of the Senate House are hung the Classes [*i.e.* the eight classes into which the candidates have been divided by the exercises in the schools; and a paper denoting the hours of examination of those who are thought most competent to contend for Honours.

"Immediately after the University clock has struck eight, the names are called over, and the absentees being marked, are subject to certain fines. The classes to be examined are called out, and proceed to their appointed tables, where they find pens, ink, and paper provided in great abundance. In this manner, with the utmost order and regularity, two-thirds of the young men are set to work within less than five minutes after the clock has struck eight. There are three chief tables, at which six examiners preside. At the first, the senior Moderator of the present year and the junior Moderator of the preceding year. At the second, the junior Moderator of the present and the senior Moderator of the preceding year. At the third, two Moderators of the year previous to the two last, or two examiners appointed by the Senate. The two first tables are chiefly allotted to the six first classes; the third or largest to the οἱ πολλοί." After describing the manner of reading out the questions, the account proceeds:—"The examiners are not seated, but keep moving round the tables, both to judge how matters proceed and to deliver their questions at proper intervals. The examination, which embraces arithmetic, algebra, fluxions, the doctrine of infinitesimals and increments, geometry, trigonometry, mechanics, hydrostatics, optics, and astronomy, in all their various gradations, is varied according to circumstances: no one can anticipate a question, for in the course of five minutes he may be dragged from Euclid to Newton, from the humble arithmetic of Bonnycastle to the abstruse analytics of Waring. While this examination is proceeding at the three tables between the hours of eight and nine, printed problems are delivered to each person of the first and second classes; these he takes with him to any window he pleases, where there are pens, ink, and paper prepared for his operations." At nine o'clock the papers had to be given up, and half an hour was allowed for breakfast. At 9.30 all returned and were examined in the same way till eleven, when the Senate House was again cleared. An interval of two hours then took place. At

[1] In such cases the Moderators called to their assistance the Proctors or other Masters of Arts. About 1770 any Master of Arts was at liberty to examine any of the candidates. Mr. Ball is of opinion that this right was not insisted on after 1785.

one o'clock all returned again and were examined. At three o'clock the Senate House was again cleared for half an hour, and on the return of the candidates the examination was continued till five o'clock. This ended the Senate House examination for the day, but at seven in the evening the first four classes went to the senior Moderator's rooms to solve problems. They were finally dismissed for the day at nine, after eight hours of examination.[1] The work on the next day (Tuesday) was similar to that of the Monday; Wednesday was devoted to logic, moral philosophy, &c. "On Thursday the examinations are resumed, and continued nearly as usual, as on the Monday and Tuesday. At eight o'clock the new classifications, or brackets, which are arranged according to the order of merit, each containing the names of the candidates placed alphabetically, are hung upon the pillars." Fresh editions and revisions of the brackets were published at 9 and 11 a.m. and at 3 and 5 p.m., according to the course of the examination, liberty being given to any man to challenge the bracket immediately above his own. At five the whole examination ended. The Proctors, Moderators, and examiners then retired to a room under the public library to prepare the list of Honours, which was sometimes settled without much difficulty in a few hours, but sometimes not before two or three the next morning. The name of the senior wrangler was generally published at midnight. In 1802 there were eighty-six candidates for honours, and they were divided into fifteen brackets, the first and second brackets containing each one name only, and the third bracket four names.

The examination seems to have been a time of great excitement, and the list was most anxiously awaited. This was the case also before 1779, as appears from the account of the contest between Paley and Frere for the senior wranglership in 1763 and Jebb's account of the examination in 1772.[2]

Various changes took place in the examination in 1808, 1828, 1833, and 1839. In 1808 another day was added: three days were devoted to mathematics, exclusive of the day of examination of the brackets. Each candidate was employed eighteen hours in the course of the three days, of which eleven were devoted to book-work and the remaining seven to problems. By regulations which were confirmed by the Senate on November 13, 1827, and came into operation in January 1828, another day was added, so that the examination extended over four days, exclusive of the day of examining the brackets; the number of hours of examination was twenty-three, the time assigned to problems being the same as in 1808. On the first two days all the candidates had the same questions proposed to them, inclusive of the evening problems, and the examination on those days excluded the higher and more difficult parts of mathematics, in order, in the words of the report, "that the candidates for Honours may not be induced to pursue the more abstruse and profound mathematics to the neglect of more elementary knowledge." Accordingly, only such questions as could be solved without the aid of the differential calculus were set on the first day, and those set on the second day involved only its elementary applications. The classes were reduced to four, determined as before by the exercises in the schools. The regulations of 1827 are specially important, because they first prescribed that all the papers should be printed.[3] They are also noticeable as being the last which gave the examiners power to ask *vivâ voce* questions: after recommending that there be not contained in any paper more questions than well-prepared students have been generally found able to answer within the time allowed for the paper, the Report proceeds: "But if any candidate shall, before the end of the time, have answered all the questions in the paper, the examiners may at their discretion propo e additional questions *vivâ voce*."

New regulations were confirmed by the Senate on April 6, 1832, and took effect in 1833. The commencement of the examination was placed a day earlier, the duration was five days, and the hours of examination on each day were five and a half. Thus four and a half hours were added to the whole time of examination, four of which were assigned to book-work and the remaining half-hour to problems. The examination on the first day was confined to subjects that did not require the differential calculus, and on the second and third days only the simple applications of the calculus were included. During the first four days of the examination the papers were set to all the candidates alike, but on the fifth day the examination was conducted according to classes. No reference is made to *vivâ voce* questions, and the examination of the brackets only survives in the permissive form: "That the result of the examination be published in the Senate House on the morning of the Friday succeeding the first Monday in Lent term, at nine o'clock; but if it should happen that the relative merits of any of the candidates are not then determined to the satisfaction of the Moderators and Examiners, that such candidates be re-examined on that day."

Only six years later these regulations were superseded by a new system, which passed the Senate on June 2, 1838, and came into operation in January 1839. By these new regulations another day was added to the examination, which thus lasted six days. The total number of hours of examination was thirty-three, of which eight and a half were given to problems. Throughout the whole examination the same papers were set to all the candidates. The regulations contain no mention of classes, and accordingly the exercises in the schools were discontinued by the Moderators. The permissive rule relating to the re-examination of the candidates (the survival from the brackets) was retained in these regulations in the same form as in those of 1832.

It is very interesting to notice, in the successive regulations, how the *vivâ voce* examination gradually merged into an examination by printed papers, and how, as the examination became more elaborate and exacting, it rendered unnecessary, not only the preliminary exercises in the schools, but also the final examination of the brackets.

Besides the development of the Senate House examination itself, other changes had taken place in the University system during this period of renewed activity. In 1824 the first Classical Tripos examination took place; only those who had already passed the mathematical examination being admissible as candidates. The name "Mathematical Tripos"[1] dates from after this year.

[1] In 1818 the hours for the evening problem paper were 6-10, so that the candidates had ten hours' examination in the day. Originally, as mentioned above, the problems were only set to the first two classes; in 1802 they were open to four classes, and in 1818 to all six classes, *i.e.* to all the candidates for Honours.

[2] Wordsworth (pp. 47 *et seq.*). See also the letters of Gooch, who was second wrangler in 1771 (p. 322).

[3] The words of the report are:—"It is further recommended that the questions from books, which have hitherto been proposed to the classes *vivâ voce*, should, for the future, be printed. And it is hoped that, as by this means the questions proposed in each year will be more generally known, the students may thus be better directed in their reading than they now are, and the mathematical studies of the University become more fixed and definite. An opportunity will also be afforded of ascertaining by an inspection of these papers that the examination embraces a due proportion of each of the ordinary subjects of mathematical study.

"As, however, in proposing this alteration, the intention of the Syndicate is to avoid making any change in the substance of the examination, it is recommended that the examiners be strictly enjoined to insert in these papers such questions only as are at present proposed *vivâ voce*; namely, propositions contained in the mathematical works commonly in use in the University, or simple examples and explanations of such propositions."

[1] There are few matters in the history of the University more curious and interesting than the manner in which the word *Tripos* came to be applied to the Senate House examination, and consequently also to the other final Honour examinations. It is natural to suppose that it is connected with the three classes into which the Honour list was divided, but there is no connection whatever. The history of the name may be given briefly as follows:—In the ceremonies which were performed on Ash Wednesday in the middle of the sixteenth century, at the admission of questionists to be Bachelors of Arts, an important function was executed by a certain "ould bachilour," who was appointed as champion on the side of the University. He had to "sit upon

Previously it had been known as the Senate House Examination, and this name continued long afterwards and for more than thirty years was still printed as a heading to the papers set. It was only as a means of distinguishing it from the Classical and other newer Triposes that the name Mathematical Tripos gradually came into use. By the regulations which took effect in 1828 a totally distinct series of papers were set to the poll-men, who then formed the fifth and sixth classes. The fiction of regarding the poll-list as a continuation of the list of mathematical honours still lingered till 1858, the names being arranged in order of merit in four classes called the fourth, fifth, sixth, and seventh; the fourth class being in theory supposed to be the next class to that of the junior optimes.

(*To be continued.*)

THE COLOURS OF METALS AND ALLOYS[1]

THIS lecture is published by request, but the author fears that, dealing as it does with the colours of metals, such interest as it may have possessed when delivered will be greatly diminished in the absence of the experiments and diagrams by which it was illustrated.

I begin with no ordinary pleasure the work which has been intrusted to me by the Council of the British Association. It is nearly twenty years since this series of lectures was established. The first, on "Matter and Force," was delivered at Dundee by a brilliant experimenter and one of the most eloquent living exponents of science; it was followed, at Norwich, by a lecture by Prof. Huxley, to whom the nation owes a deep debt of gratitude for his intense sympathy with all who are seeking to widen the bounds of scientific knowledge—to be whose colleague in one of the most important scientific schools of the country is my great good fortune. These lecturers were succeeded by other eminent men, among whom may be mentioned Spottiswoode, Bramwell, and Lubbock. The object of the lectures is to diffuse a knowledge of the operations of Nature, and to add to the number of those who rejoice in her works. Many, therefore, who have spoken to audiences similar to this, have appealed to natural phenomena; and instead of talking to you about the colour of metals, I also should have liked to dwell on the colour of the sea and sky, but Ruskin's works are, I know, often in your hands, and he has told you once for all of the colour of clouds that "there is not a moment of any day of our lives when Nature is not producing scene after scene, picture after picture, glory after glory, and working still upon such exquisite and constant principles of the most perfect beauty that it is quite certain it is all done for us, and intended for our perpetual pleasure."[1] The metallurgist, however, cannot speak with authority on themes such as these; and I have therefore selected a subject which will, I believe, enable me to bring before you important truths affecting a wide range of industrial operations, and at the same time to sustain the true function of art by pointing to the direction in which we may have increased pleasure in things that constitute our most ordinary possessions, and which we use in daily life. First permit me to explain that I intend to include under the title of the lecture any facts which are, in my opinion, connected with the colours of metals and alloys, whether natural to them or produced by artifice, as well as a brief examination of the influence which the colours of metals appear to have exerted on the history of science.

I propose to begin at what will appear to be a somewhat remote starting-point. We say that copper is red, gold yellow, and silver white, but it is by no means certain that the early races of the world had any very clear perception of the difference between these several metallic colours. With regard to early Hebrew and Greek civilisation, Mr. Gladstone has expressed his belief that the colour-sense—that is the power of recognising colour and distinguishing it from mere brightness or darkness—was imperfectly developed, and he considers that "the starting-point is absolute blindness to colour in the primitive man," and he urges that the sense of colour has been gradually developed "until it has now become a familiar and unquestioned part of our inheritance." He adds: "Perhaps one of the most significant relics of the older state of things is to be found in the preference (known to the manufacturing world) of the uncivilised nations for strong and, what is called in the spontaneous poetry of trading phrases, loud colour."[2]

Dr. Magnus holds the view that the colour-sense in man has undergone a great improvement within the last 2000 years, and Prof. Haeckel supports this speculation, but it is opposed by Romanes, who has favoured me with some observations on the subject, in view of this lecture; and it seems to me strange, if savage nations are really deficient in the sense of colour, that the use of such colours as they can get in metals and fabrics, blended, for instance, in a war-club or a pipe-stem, should be so thoroughly "understood" and so discriminatingly employed as we sometimes find them to be. It may further be observed that primitive man may even have derived from his more remote ancestry some power of being influenced by colour, and we are told that the attraction which gorgeous colouring in flowers has for birds and insects, and which colour generally possesses for our nearer ancestors, has been of great importance in the origin of species, and in the maintenance of organic life.

No doubt, in ancient times, there was much confusion between mere brightness and colour, such as is evident in the beautiful sentence in which St. Augustine[3] says: "For this *queen of colours, the light*, bathing all which we behold, wherever I am through the day, gliding by me in varied forms, soothes me when engaged on other things and not observing her." If, however, it were proved that the power of distinguishing the colour of metals was not widely diffused among the Egyptians, Hebrews, and Greeks, it is at least certain that there were individuals of these nations to whom, in very early times, the colour of metals was all-important; and although they may have confused different precious stones under generic names, they certainly appreciated their various colours, and knew, moreover, that by fusing sand with the addition of a small quantity of certain minerals, they could produce artificial gems of varied tints.

a stoole before Mr. Proctours" and to dispute with the "eldest son" (the foremost of the questionists), and afterwards with "the father" (a graduate of the College to which the "eldest son" belonged, representing the paternal character of the College). At this time the only "Tripos" was the three-legged stool on which the Bachelor sat. A century later this Bachelor seems to have become a sort of licensed buffoon, and to have been called "Mr. Tripos," just as a president is sometimes referred to as "the Chair," or a judge as "the Bench." During the 120 years in which the name Tripos or Tripus indicated a personage there are frequent allusions to the humorous orations delivered in the schools by those who filled this office. These were known as Tripos speeches. It is probable that Mr. Tripos ceased to take part in the arguments in the schools between 1730 and 1750, just about the time when the Senate House examination was originating. The Tripos speeches were then replaced by copies of Latin verses, which were circulated on the admission days. These were called Tripos verses. About 1747 the Moderators began the custom of printing Honour lists on the back of the Tripos verses. Thus the list of Honours in the Senate House examination came to be called the Tripos list, so that a man's name was said to stand in such a place in the Tripos of his year, *i.e.* upon the back of the Tripos verses. And, lastly, the name was transferred from the list to the examination, the results of which were published in the list. This account is abridged from Wordsworth's *Scholæ Academicæ*, chap. ii. Wordsworth concludes: "Thus, step by step, we have traced the word *Tripos*, passing in signification, Proteus-like, from a thing of wood (*olim truncus*) to a man, from a man to a speech, from a speech to two sets of verses, from verses to a sheet of coarse foolscap paper, from a paper to a list of names, and from a list of names to a system of examination."

[1] A Lecture delivered on September 3 by Prof. W. Chandler Roberts-Austen, F.R.S., to the Operative Classes in the Town Hall of Birmingham, in connection with the meeting of the British Association.

[1] "Modern Painters," vol. i. part 2, p. 201, 1851.

[2] *Nineteenth Century*, p. 367, 1877.

[3] "Confessions of St. Augustine." Edition edited by E. B Pusey, D.D. (p. 211).

My object in leading you so far back—in discussing what appears to be a very matter-of-fact subject—is to point to the close connection between the early recognition and appreciation of colour in metals or minerals, and the foundation of the science of chemistry.

In early scientific history the seven metals known to the ancients were supposed to be specially connected with the seven principal planets whose names they originally bore, and whose colours were reflected in the metals; thus gold resembled the sun, silver the moon, while copper borrowed its red tint from the ruddy planet Mars. The belief in the intimate relation between colours and metals, the occult nature of which they shared, was very persistent, and we find a seventeenth-century writer, Sir John Pettus, saying[1] that "painters" derive "their best and most proper colours from metals whereof seven are accounted the chief, produced from the seven chief metals, which are influenced by the seven planets." A survival of this feeling is suggested by a modern writer, Leslie, who supposed that "when Newton attempted to reckon up the rays of light decomposed by the prism, and ventured to assign to them the famous number seven, he was apparently influenced by some lurking disposition towards mysticism."[2]

It would be impossible for me to overrate the importance of the colour of metals in relation to scientific history, for the attempt to produce a metal with the colour and properties of gold involved the most intense devotion to arduous research sustained by feverish, hope, attended by self-deception and elaborate fraud, such as hardly any other object of human desire has developed. It led to despair, to madness, and to death; but finally, through all, alchemy prepared the way for the birth of chemistry, and for the true advancement of science.

In early times, as now, gold was an extremely desirable form of portable property, and its colour was, perhaps, held to be the most distinctive and remarkable fact about it. I may incidentally observe that the dominant idea of colour in connection with the metallic currency survives in the familiar phrase, "I should like to see the *colour* of his money," which curiously expresses a desire, tempered by doubt as to its fulfilment. On looking back, we find that, at least from the third to the seventeenth century, the colour of gold haunted the early experimenters, and induced them to make the strangest sacrifices, even of life itself, in the attempt to imitate, and even actually to produce, the precious metal. Let us see what kind of facts were known within the period I have indicated. In barbaric times, hammered pieces of gold, or gold beaten into thin sheets and plates, were used with coloured stones and coral for personal adornment. The next step was to make gold go further by gilding base metals with it, and, in order to do this, the colour was for the moment sacrificed by combining the gold with quicksilver. This was done at least in the time of Vitruvius, B.C. 80, heat being used to drive away, as vapour, the quicksilver which had been united to the gold, leaving a thin film of precious metal on the surface to be gilded. But this was possibly not the first method of gilding, for we now know, from a papyrus of about the third century[3] of our era, that lead was used for this purpose. Gold, when fused with lead, entirely loses its golden colour, and yet, by the application of heat in air, the lead may be made to flow away as a fusible oxide, leaving the precious metal on the metallic object to be gilt, the base metal being as it were transmuted, superficially at least, into gold. The point I want to insist upon is that the metallic colour of the gold vanished during the process as carried on by the craftsman, only to re-appear at the end of the operation; and I am satisfied that it was from such simple technical work as this that the early chemists were led to think that the actual production of gold—the transformation of base metals into gold—was possible. The more observant of them, from Geber, the great Arabian chemist of the seventh century, to our own countryman, Roger Bacon, in the thirteenth, saw how minute a quantity of certain substances would destroy the red colour of copper, or the yellow colour of gold. A trace of arsenic will cause the red colour of copper to disappear; therefore, the alchemists very generally argued, some small quantity of the right agent, if only they could find it, will turn a base metal to the colour of gold. Look, they said, how small a quantity of quicksilver will change the appearance of metallic tin. Here is a bar of tin 2 feet long and 1 inch thick, which it would be most difficult to break, though it will readily bend double. If only I rub a little quicksilver on its surface a remarkable effect will be produced, the fluid metal will penetrate the solid one,[1] and in a few seconds the bar will, as you see, break readily, the fractured surface being white, like silver. It was by such facts as this that men were led to believe that the white metal, silver, could be made.

[1] "Fleta Minor," 1686, Appendix, "Essay on Metallic Words.—Colour."

[2] "Treatises on Various Subjects of Natural and Chemical Philosophy."

[3] "Les Origines de l'Alchimie," par M. Berthelot, 1885, pp. 82, 89. It is interesting to compare the account of this method of gilding by lead with the expression used by Homer, who says: "As when gold is *fused* around the silver by an experienced man."—"Odyssey," vi. 232-35, quoted by Schliemann, "Ilios," p. 258, in relation to a gilded knife of copper which he permitted me to analyse in 1878.

Successive workers at different periods held divergent views as to the efficacy of the transmuting agent. Roger Bacon, in the thirteenth century, held that one part of the precious substance would suffice to turn a million parts of base metal into gold. Basil Valentine, in the fourteenth century, would have been content with the transmutation of seventy parts of base metal by one part of the agent. While, coming to the end of the eighteenth century, Dr. J. Price, F.R.S., of Guildford, only claimed that the substance he possessed would transmute from thirty to sixty parts of base metal.[2]

It is a curious fact that no one seems to have actually prepared the transmuting agent for himself, but to have received it in a mysterious way from "a stranger"; but I must not dwell on this. I will merely point out how persistent was the view as to the singular efficacy of the transmuting agent, and I will content myself with a reference to Robert Boyle, our great countryman, an accurate chemist of the seventeenth century, who did more than any one else to refute the errors of alchemy. He nevertheless characteristically records[3] the following experiment, in which, instead of ennobling a base metal, he apparently degraded gold to a base one. He first purified a small quantity of gold, about "two drachms," with great care, and, he states, "I put to it a small quantity of powder communicated to me by a stranger,"—it is singular that even he should have received the transmuting agent in the usual way,—"and," he adds, "continuing the metal a quarter of an hour on the fire, that the powder might diffuse itself through it, . . . the metal when cold appeared to be a lump of *dirty colour;* . . . 'twas brittle, and, being worked with a hammer, it flew into several pieces. From hence," he adds, "it appears that an operation almost as strange as that called 'projection'" (or transmutation) "may safely be admitted, since this experiment shows that gold, . . . the least mutable of metals, may in a short time be exceedingly changed . . . by so small a portion of matter that the powder transmuted a thousand times its weight of gold." He elsewhere observes of a similar experiment, "transmutation is nevertheless real for not being gainful, and it is no small matter to remove the bounds which Nature seems very industriously to have set to the alterations of bodies."[4] The change in the

[1] Homberg, *Mém. de l'Acad. Royale des Sciences*, 1713 (vol. published 1739), p. 306.

[2] "An Account of some Experiments on Mercury, Silver, and Gold made at Guildford, in the Laboratory of James Price, M.D., F.R.S.," Oxford, 1782.

[3] "The Philosophical Works of the Hon. Robert Boyle" (Shaw's second edition), 1738, vol. i. p. 78.

[4] *Ibid.* p. 262.

colour of the gold was remarkable, but Boyle had only produced one of the series of alloys most dreaded by every jeweller—"brittle gold"—for the way in which an alloy of gold and copper is affected by a small quantity of impurity presents one of the most serious difficulties in working gold. It has been known since the seventh century, that minute quantities of certain metals render gold brittle, and it may be well to demonstrate the fact.

Here are two hundred sovereigns: I will melt them and will add in the form of a tiny shot a minute portion of lead amounting to only the 2000th part of the mass, first, however, pouring a little of the gold into a small ingot, which we can bend and flatten, thus proving to you that it is perfectly soft, ductile, and workable. The rest of the mass we will pour into a bar, and now that it is sufficiently cold to handle, you see that I am able to break it with my fingers, or at least with a light tap of a hammer. The *colour* of the gold is quite altered, and has become orange-brown, and experiments have shown that the tenacity of the metal, that is, the resistance of the gold to being pulled asunder, has been reduced from 18 tons per square inch to only 5 tons. These essential changes in the property of the metal have been produced by the addition of a minute quantity of lead. I have cited these facts mainly to show that the changes produced in the colour and properties of metals by small variations of composition were such as to lead the alchemists on in their belief that it was possible to change lead or tin into gold, and the hope in which they worked enabled them to gather facts out of which chemical science was gradually constructed. We shall see presently that changes in the colour of metals and alloys produced by the addition of small quantities of foreign matter, are of great importance in the application of metals to artistic purposes, but we must first try to examine more closely some of the prominent facts connected with the colour of metals, that is, the effect metals have on light so as to produce the effect of colour in our eyes. We are apt to think of gold as being essentially and distinctively golden-yellow; it may, however, possess a wide range of colours without in any way losing the condition of absolute metallic purity, its relations to light depending entirely on the nature of its surface, and especially on whether the metal is in mass or in a more or less fine state of division. Interesting as gold is to us in mass (and I may incidentally mention that during my official connection with the Mint I have been responsible for the quality of 462 tons of it) it is perhaps still more interesting to us when beaten so fine that a single grain, of the value of 2*d*., would cover a space of 48 square inches, or when it is so finely divided that the dimensions of a single particle may closely approximate to those of the ultimate atom.

This aspect of the question was investigated by Faraday, and the experimental part of the subject remains practically unadded to since his time. It is well known that a leaf of gold when seen by transmitted light is either green or blue, according to its thickness. Here is such a leaf of green gold, as seen when light is actually sent through it (Fig. 1), so as to project a green disk on the screen. A portion of the light will be *reflected* from its surface, and this reflected ray may be caught in a mirror and thrown on the screen so that you have, shown side by side, the green disk of transmitted light and the golden one of reflected light from the same leaf of gold.

Gold may readily be converted into a soluble chloride which produces a beautiful golden solution. If such a solution contains very little gold, not more than 2 grains in a gallon, and if certain chemical methods be adopted to precipitate the gold, that is, to throw it out of solution in a *solid*, though in a very fine state of division, the metal may exhibit a wide range of tint, from ruby to black.

[A few drops of phosphorus dissolved in bisulphide of carbon had been added to about a gallon of a very dilute solution of chloride of gold contained in a tall glass cylinder, as shown in the sketch (Fig. 2). The beam from an electric light, thrown through the vessel, revealed in the lower part the presence of finely-divided metal of the natural golden colour, while the more finely-divided gold in suspension imparted a brilliant ruby colour to the liquid, and a glowing ruby disk was projected on a white screen.]

When gold is in the "ruby" state, it is so finely divided that each particle probably approximates to the dimensions of the gold atom.

[The solar spectrum was then thrown upon the screen, and the audience was invited to compare it with a diagram which, while closely resembling the solar spectrum,

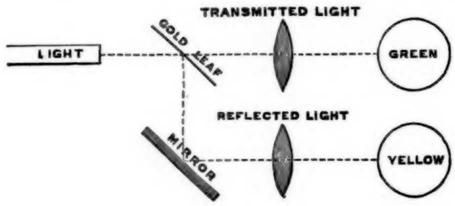

FIG. 1.

really represented the way in which pure metallic gold, prepared by various methods, is capable of behaving in relation to light so as to produce the sensation of a wide range of colours.]

It would be easy to show that light is similarly affected by other metals; but I have selected gold for the purpose of illustration because it is easy to maintain it in a state of purity, however finely divided it may be. We must therefore modify any views we may have formed as to a metal having exclusively a special colour of its own, because it

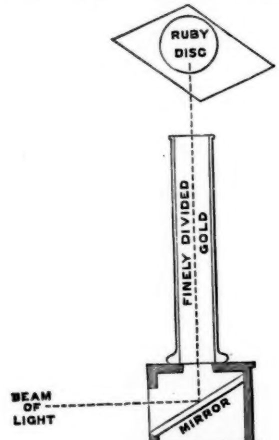

FIG. 2.

will be evident that a particular colour is only due to a definite state of arrangement of its particles. The intimate relation between the state of the surface of a metal and its colour is well shown by the beautiful buttons devised by Sir John Barton. He proved that if very fine lines be drawn close together, so that about 2000 would be ruled in the space of an inch, a beautiful iridescent effect is produced, the tints being quite independent of the metal itself due to an optical effect of the lines.

[The image of such a button was then thrown upon the screen

Let us now examine some effects of uniting metals by fusing them together into what are called alloys; and, second, the direct influence of a minute quantity of one metal in changing the mass of another in which it is hidden, and causing it to behave in a different way in relation to light, and consequently to possess a colour different from that which is natural to it; or the added metal may so change the chemical nature of the metallic mass that varied effects of colour may be produced by the chemical combinations which result from the action of certain "pickling" solutions. This portion of the subject is so large that I can only hope to set before you certain prominent facts.[1]

First, with reference to the colour produced by the union of metals. Here is a mass of red copper, and here one of gray antimony: the union of the two by fusion produces a beautiful violet alloy when the proportions are so arranged that there is 51 per cent. of copper and 49 per cent. of antimony in the mixture. This alloy was well known to the early chemists, but unfortunately it is brittle and difficult to work, so that its beautiful colour can hardly be utilised in art. The addition of a small quantity of tin to copper hardens it, and converts it, from a physical and mechanical point of view, into a different metal. The addition of zinc and a certain amount of lead to tin and copper confers upon the mettal copper the property of receiving, when exposed to the atmosphere, varying shades of deep velvety brown, characteristic of the bronze which has from remote antiquity been used for artistic purposes. But by far the most interesting copper alloys, from the point of view of colour, are those produced by its union with zinc, namely brass. Their preparation demands much care in the selection of the materials, and I might have borrowed from the manufacture of brass instance after instance of the influence of traces of impurity in affecting the properties of the alloy, but it is unnecessary to dwell upon this alloy in Birmingham, for in all that relates to the mechanical manipulation of the alloys of copper with tin and with zinc, you are masters. I have many inducements in this place to speak about this beautiful alloy. I am proud to be a namesake of the craftsman, William Austen, who, in 1460, made that magnificent monument in brass which covers the remains and commemorates the greatness of Richard Beauchamp, Earl of Warwick, and I am glad to remember that Queen Elizabeth granted the first patent for the manufacture of brass in England to William Humfrey, Assay Master of the Mint, a predecessor in the office it is my privilege to hold.

I want, however, to direct your attention to-night to some alloys of copper with which you are probably less familiar than with brass. In this direction Japanese art affords a richer source of information than any other. Of the very varied series of alloys the Japanese employ for art metal-work, the following may be considered to be the most important and typical. The first is called "shaku-dō"; it contains, as you will observe from Analyses I. and II.,[2] in

Shaku-dō.

I.		II.	
Copper	94·50	Copper	95·77
Silver	1·55	Silver	0·08
Gold	3·73	Gold	4·16
Lead	·11		100·01
Iron and Arsenic	traces		
	99·89		

addition to about 95 per cent. of copper, as much as 4 per cent. of gold. It has been used for very large works. Colossal statues are made of it; one cast at Nara in the seventh century being specially remarkable. The quantity of gold is, however, very variable; specimens I have analysed contained only 1·5 per cent. of the precious metal. The next alloy to which I would direct your attention is called "shibu-ichi." There are numerous

Shibu-ichi.

III.		IV.	
Copper	67·31	Copper	51·10
Silver	32·07	Silver	48·93
Gold	traces	Gold	·12
Iron	·52		
	99·90		100·15

varieties of it, but in both these alloys, shaku-dō and shibu-ichi, the point of interest is that the precious metals are, as it were, sacrificed in order to produce definite results; gold and silver, when used pure, being employed very sparingly to heighten the general effect. In the case of the shaku-dō, we shall see presently the gold appears to enable the metal to receive a beautiful rich purple coat or *patina*, as it is called, when treated with certain pickling solutions; while shibu-ichi possesses a peculiar silver-gray tint of its own, which, under ordinary atmospheric influences, becomes very beautiful, and to which the Japanese artists are very partial. These are the principal alloys, but there are several varieties of them, as well as combinations of shaku-dō and shibu-ichi in various proportions, as, for instance, in the case of kiu-shibu-ichi, the composition of which would correspond to one part of shaku dō rich in gold, and two parts of shibu-ichi rich in silver. Interesting effects are produced by pouring two alloys of different tints together just at the solidifying point of the less fusible of the two, so that the alloys unite but do not blend, and a mottled surface is the result. These alloys are introduced into almost every good piece of metal-work.

Now as to the action of pickling solutions. Many of you will be familiar with the mysteries of the treatment of brass by "dipping" and "dead dipping," so as to produce certain definite surfaces, but the Japanese art metal-workers are far ahead of their European brothers in the use of such solutions.

The South Kensington Museum contains a very valuable series of fifty-seven oblong plates, some plain and others richly ornamented, which were specially prepared as samples of the various metals and alloys used by the Japanese. The Geological Museum in Jermyn Street has a smaller, but very instructive, series, of twenty-four plates presented by an eminent metallurgist, the late M. Hochstätter-Godfrey. From descriptions accompanying the latter, and from information I have gathered from certain Japanese artificers now in London, it would appear that there are three solutions generally in use. They are made up respectively in the following proportions, and are used boiling.

	I.	II.	III.
Verdigris	438 grains	87 grains	220 grains
Sulphate of copper	292 ,,	437 ,,	540 ,,
Nitre	—	87 ,,	—
Common salt	—	146 ,,	—
Sulphur	—	233 ,,	—
Water	1 gallon	—	1 gallon
Vinegar	—	1 gallon	5 fluid drachms

That most widely employed is No. I. When boiled in No. III. solution, pure copper will turn a brownish red; and shaku-do, which, you will remember, contains a little gold, becomes purple; and now you will be able to appreciate the effect of small quantities of metallic impurity as affecting the colour resulting from the action of the pickle. Copper containing a small quantity of antimony gives a shade very different from that resulting from the pickling of pure copper. But the copper produced in Japan is the result of smelting complex ores, and the

[1] A list of books and papers dealing with the colours of metals and alloys, and with the production of coloured patina, is given by Prof. Ledebur in his work "Die Metallverarbeitung," p. 285, 1882, published in Bolley's "Technologie."

[2] Analyses Nos. I. and III. are by Mr. Gowland, of the Imperial Japanese Mint at Osaka; Nos. II. and IV. by Prof. Kalischer, *Dingl. Polyt. Journ.*, ccxv. 93.

methods of purification are not so perfectly understood as in the West. The result is that the so-called "antimony" of the Japanese art metal-workers, which is present in the variety of copper called "kuromi," is really a complex mixture containing tin, cobalt, and many other metals, so that a metal-worker has an infinite series of materials at command with which to secure any particular shade; and these are used with much judgment, although the scientific reasons for the adoption of any particular sample may be hidden from him. It is strictly accurate to say that each particular shade of colour is the result of minute quantities of metallic impurity, and these specimens and diagrams will, I trust, make this clear, and will prove that the Japanese arrange true pictures in coloured metals and alloys.

[This portion of the subject was illustrated with much care by coloured diagrams representing specimens of Japanese art metal-work, by photographs projected on the screen, as well as by the reflected images of small ornaments made of the alloys which had been specially referred to. There was also a trophy of leaves of copper of varying degrees of purity coloured brilliantly by one or other of the "pickles" above described.]

There is one other art material to the production of which I hope art workmen in Birmingham will soon direct their attention, as its applications are endless. It is called in Japanese "mokume," which signifies "wood-grain." It is now very rare even in Japan, but formerly the best specimens appear to have been made in Nagoya by retainers of the Daimio of Owari. I have only seen six examples, and only possess a single specimen of native work, and have therefore had to prepare a few illustrations for you in soldered layers of gold, silver, shibu-ichi, shaku-dō, and kuromi.

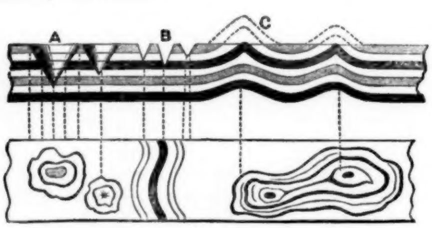

FIG. 3.

This diagram (Fig. 3) shows the method of manufacture. Take thin sheets of almost any of the alloys I have mentioned, and solder[1] them together layer upon layer, care being taken that the metals which will present diversity of colour come together. Then drill conical holes of varying depth, A, in the mass, or devices in trench-like cuts of V section, B, and hammer the mass until the holes disappear; the holes will thus be replaced by banded circles and the trenches by banded lines. A Japanese artificer taught me to produce similar effects by taking the soldered layers of the alloy, and by the aid of blunted tools making depressions on the back of the mass so as to produce prominences on the front, C. These prominences are filed down until the sheet is again flat; the banded alloys will then appear on the surface in complicated sections, and a very remarkable effect is produced, especially when the colours of the alloys are developed by suitable "pickles." In this way any device may be produced. In principle the method is the same as that which produces the *damascening* of a sword-blade or gun-barrel, and depends on the fact that under certain conditions metals behave like viscous solids, and as truly "*flow*" as pitch or honey does, only in the case of mokume the art workman has a wide range of tinted metals at command.

Throughout Japanese art metal-work, in which I hope you will take increasing interest, there is the one principle of extreme simplicity and absolute fidelity to nature. The brilliant metals, gold and silver, are used most sparingly, only for enrichment, and to heighten the general effect; these precious metals are never allowed to assert themselves unduly, and are only employed where their presence will serve some definite end in relation to the design as a whole. A Japanese proverb asserts that "He who works in gold puts his brains into the melting-pot," meaning, I suppose, that this metal, so precious from an artistic point of view, demands for its successful application the utmost effort of the workman, and suggesting that gold should not be employed in massive forms such as would result from melting and casting, but should be daintily handled, beaten on to the work, or embedded with the hammer.

Bear in mind that in Birmingham, when a really fine work is produced in silver, the surface is often made gray by chemical means, "oxidised," as it is termed, and this subordination of the brilliancy of silver to artistic effect, is well understood by the celebrated American firm, Messrs. Tiffany, of New York, who are doing so much to catch the spirit of Japanese art metal-work. All I ask you to do is to carry this still further—to cover base metals with these glowing coloured oxides, and thus to add to the permanence of art work, by producing surfaces which will resist the unfavourable atmospheric influences of our cities.

Hitherto we have considered the union of metals by fusion, but fire is not the only agent which can be employed for this purpose. Two or more metals may be deposited side by side by the aid of the electric battery. Birmingham was, as you well know, the early home of electro-metallurgy, an industry to the development of which the great firm of Elkington has so materially contributed. I have no statistics as to the amount of precious metals annually employed for electro-deposition in Birmingham, but it is known that a single works in Paris, belonging to M. Christofle, deposits annually six tons of silver, and it has been estimated that the layer of silver of the thickness actually deposited on various articles would, if spread out continuously, cover an area of 140 acres.[1] I will not, however, dwell upon the deposition of gold and silver in their normal colours. I would remind you that copper and zinc may be deposited by electrolysis so as to form brass, and that all the beautiful bronzes and alloys of the Japanese can be obtained by galvanic agency; and further, by suitable admixtures of gold, silver, and copper, red-gold, rose-coloured gold, or green gold may be deposited, so that the electro-metallurgist has at his command the varied palette of the decorative artist.

[The images of beautiful deposits of coloured gold, specially prepared by Messrs. Elkington, were then projected on the screen.]

I ought to allude to what has been called the moral aspect of colour, and although I cannot follow Goethe[2] in his attributes of colour, which seem to me to be fantastic and over-strained, I quite recognise the poetic sympathy of Shakespeare in making Bassanio select the casket of lead, which contained the warrant for his earthly happiness, because "its paleness moved him more than eloquence." I ask you to remember Ruskin's words, that "all men completely organised and justly tempered enjoy colour; it is meant for the perpetual comfort and delight of the human heart; it is richly bestowed on the highest works of creation, and the eminent sign and seal of perfection in them being associated with life in the

[1] The following solder was found to answer well:—

Silver	55·5
Zinc...	26·0
Copper	18·5
	100·0

[1] H. Bouilhet, *Ann. de Chim. et de Phys.* t. xxiv. p. 549, 1881.
[2] Farbenlehre.

human body, with light in the sky, with purity and hardness in the earth; death, night, and pollution of all kinds being colourless."

I must briefly turn to the concluding part of our subject. It has long been known that thin films of certain metals and certain metallic oxides act on light in the same way as thin films of other translucent substances. I have here such thin films of oxide of lead, which, many years ago, Nobili, Becquerel, and Gassiot taught us to deposit, and such films have since been used in decorative metal-work.

[Beautiful examples of such films were projected on the screen.]

I wish I had time to point to the great interest and importance of films of coloured oxide of iron in the tempering of steel, for it is well known that, apart from the scientific interest of the subject, the shades from straw-colour to blue which pass over the surface of hardened steel when it is heated in air, afford precious indications as to the degree of temper the metal has attained, and in no industry is this better shown than in the manufacture of steel pens. I must pass this over, and turn to one other instance of the formation of coloured films on metals. Here is an ordinary plumber's ladle filled with lead, which will soon be molten when it is placed over this flame. The air will play freely on the surface of the melted lead, and, as a certain temperature is reached, very beautiful films will pass over the surface of the metal. If the lead contains very minute quantities of cadmium or of antimony, the effect will be greatly heightened. If the light from the electric lamp be allowed to fall on the surface of the bath of lead, it will be easy to throw the image of the metallic surface on the screen, and you will see how beautiful the films are and how rapidly they succeed each other when the metal is skimmed. What, then, is the special significance of the experiment from our point of view? It represents in a singularly refined way the one experiment which stands out prominently in the whole history of chemistry; for the formation of a coloured scum on lead when heated in air has been appealed to, more thany any other fact, in support of particular sets of views from the time of Geber in the seventh century to that of Lavoisier in the eighteenth. It was the increase in weight of the lead when heated in air that so profoundly astonished the early chemists; and, finally, the formation of a coloured oxide by heating lead in air was the important step which led on your great townsman, Priestley,[1] to the discovery of oxygen; and, as the fact of his residence among you will never be forgotten, Birmingham may claim to have been connected, through him, with one of the most splendid contribution ever offered to Chemical Science.

NOTES

PROF. RÜCKER, F.R.S., has been appointed by the Lord President of the Council to the Professorship of Physics in the Normal School of Science and Royal School of Mines, rendered vacant by the death of Prof. Guthrie, F.R.S.

AT the Royal Society on Thursday last (November 25) a paper was read by Sir Richard Owen, containing some further evidence on the structure of the very remarkable extinct marsupial, *Thylacoleo carnifex*. The author re-affirmed his previous statements that it was a carnivorous beast of the size of a lion, the probable prey of which had been the larger herbivorous marsupials, also now extinct. Prof. Flower, after reviewing the additional evidence that had been adduced, repeated his conviction expressed eighteen years ago in a paper read before the Geological Society, that the dentition of *Thylacoleo* found no parallel in any existing predaceous carnivore, but was formed on a totally different type, and that there was therefore no justification for assigning to it habits for which it did not seem particularly well adapted. The essential conditions in a dentition which would enable an animal to seize and overcome large and struggling prey, as seen in both lions, tigers, wolves, and the existing carnivorous marsupials, are large canines set well apart, with incisors so small as not to interfere with their piercing action; whereas in *Thylacoleo* the canines are rudimentary, and the central incisors greatly developed. The alternative, sometimes suggested, that the animal was herbivorous, was equally improbable. In fact, it would not be safe to do more than speculate on the habits or food of an animal the dentition of which was so highly specialised, and without any analogy in the existing state of things. Prof. Huxley said that he agreed with the conclusions of the last speaker.

A COURSE of six lectures, adapted to a juvenile auditory, on "The Chemistry of Light and Photography" (with experimental illustrations), will be given at the Royal Institution by Prof. Dewar, M.A., F.R.S., on the following days, at three o'clock:—Tuesday, December 28, 1886; Thursday, December 30; Saturday, January 1, 1887; Tuesday, January 4; Thursday, January 6; Saturday, January 8.

THE Royal Society have just received from Egypt a consignment of specimens of the different strata of soil in the Delta. The borings have been carried out to a depth of nearly 200 feet, and the solid bottom has not yet been reached. The Royal Engineers in Egypt have been intrusted with the work. The specimens, which are chiefly of sand and clay strata, are deemed of great importance, and the Society has granted money for the continuance of the work, which will be carried out by the detachment of Engineers as hitherto.

THE Secretary of State for War has given permission for Sir Frederick Abel, C.B., the Chemist of the War Department, to accept the post of organising secretary to the Imperial Institute, provided that the duties do not interfere with those of his appointment under the War Office; and Sir Frederick Abel has been desired by the Prince of Wales, President of the Imperial Institute, to enter upon his work as soon as possible. The new secretary has just completed his work in connection with the electric lighting of the Indian and Colonial Exhibition, and is also retiring from his duties in connection with the Society of Arts.

ON November 17, at 7h. 18m. p.m., a fine fireball was seen at Stonyhurst College, Blackburn. It appeared to be several times as bright as Venus. In colour it was violet, and of a distinct pear shape. The part of its path observed, as far as could be judged from the stars seen through detached clouds, was from near ι Ceti to the small stars above Fomalhaut, about 88 Aquarii. Its path was slightly curved. So brightly did it shine that attention was first called to it by the illumination of the sky, although seen from a room in which the gas was lighted.

THE *Morning Star* of Jaffna, in Ceylon, reports the death of the taxidermist of the Victoria Museum in that town from the bite of a cobra, under very curious circumstances. While feeding a cobra, which he had supposed was harmless from previous extraction of the poison-bag, it suddenly bit his hand. For a few minutes he took no notice, thinking the bite harmless, but pain and nausea soon began. Carbolic acid was applied, ligatures were bound round the arm, an incision was made at the bite, and the blood of the arm was wholly removed. Various antidotes were used, but the unfortunate man lost the power of speech, and soon after every muscle seemed to have become paralysed, and breathing entirely ceased.

[1] He pointed out that the experiment with minium confirmed his view that he mercury calcined in air derived oxygen *from* the air.

Artificial respiration was therefore resorted to, and this operation was unceasingly continued for nine hours, when at last the patient made an attempt to breathe, and soon regained consciousness enough to make his wants known. He steadily improved until the Friday, the accident having taken place on a Wednesday, and then astonished those around him by stating that during the severe operation of Wednesday night he was conscious of all that was taking place, but was unable to make his feelings known, not having power over a single muscle. It would seem that the poison paralysed the nerves of motion, but not those of feeling, for he could see, and hear, and feel, although the physicians, even by touching the eyeball, could get no response either of feeling or consciousness. His partial recovery was, however, followed by a high fever and inflammation of the lungs, and he died, perfectly conscious, on the following Sunday.

THE New Zealand Government are about to collect salmon ova in Scotland and transfer them to that colony for incubation. It will be remembered that the Royal Commissioner for New Zealand has previously carried out similar work successfully, and it has been found that the *S. salar* thrives well in the waters of that possession. Last year a large number of salmon ova were collected from Scotland, and hatched out and reared in New Zealand.

COMMENCING on January 1, 1887, a journal is to be published by the National Fish-Culture Association, comprising not only information regarding its transactions from time to time, but also articles relative to the subjects of fish-culture, fish, and fisheries. A record will also be given of what takes place in connection with these subjects throughout the whole of the United Kingdom, the colonies, and abroad.

A STRONG shock of earthquake, lasting several seconds, was felt at Smyrna and in the adjacent districts early on the morning of November 27, and news has been received of Tchesme and Chios having been similarly visited. A strong shock was felt at Tashkend on the morning of November 29, causing damage to many houses in the Russian quarter. Two shocks were felt on Sunday at Somerville and at Charleston. A slight shock was felt in Cairo at half-past four o'clock on the afternoon of the 17th. The vibration lasted several seconds.

DURING the past summer, Dr. Fr. Svenonius, the well-known Swedish geologist, has been prosecuting geological, ethnographical, and glacial studies in Swedish Lapland.

ON the evening of November 4 a splendid display of the aurora borealis was seen at Throndhjem, in Norway. Not only the northern, but also the eastern and part of the southern, sky were covered with aurora. The radiation was particularly brilliant from south-west to north-east, forming a wreath in all the colours of the rainbow. During October, several splendid displays of aurora occurred, but none as brilliant as this one.

ON the evening of October 30 a brilliant meteor was seen from the Faloterbo lightship, on the south-west coast of Sweden. It went in a direction south-south-west to north-north-east, exploding, as it seemed, from time to time, and displaying the most brilliant yellow, red, and green light. At times the sky was illuminated as in full moonlight. About a couple of minutes after the last explosion, reports as of guns were heard. At about 2 a.m. of November 5 another splendid meteor was seen at Hamar, in Norway. It went in a southerly direction across Lake Mjösen, and disappeared from view, leaving a long, broad, variegated trail behind.

PROF. COLLETT, the well-known Norwegian zoologist, announces that the beaver is now extinct in Northern Norway, but estimates that about 100 are still in existence in the south, chiefly in the province of Nedenaes.

A KITCHEN-MIDDEN has just been discovered at Ginnerup, in Denmark, at the foot of a cliff near a dried-up sound. It is about a yard in depth and of considerable extent, and contains quantities of shells of oysters, mussels, &c.

THE last numbers of the *Journal* of the China Branch of the Royal Asiatic Society (vol. xxi. Nos. 1 and 2) contain a "Symposium" on the question whether Western knowledge, and especially, of course, Western science, should be conveyed to the Chinese through the medium of their own or of a Western language. Fourteen of the leading European scholars in China took part in the discussion. Their views will not bear classification under the heads affirmative or negative, as some hold a middle place, exhibiting a leaning in one direction or another. The general tendency, however, is in favour of exciting the curiosity and interest of intelligent Chinese in the matter of Western knowledge by popular exposition in the native tongue, while reserving a more adequate representation for a time when a sufficient number of Chinese shall have acquired foreign languages to constitute a learned class in our sense of the expression. A further and final stage will be reached when the members of this class, themselves impregnated with foreign knowledge, shall convey it to their fellow-countrymen in their own tongue, gradually modified to suit the exigencies of doctrines now absolutely foreign to the genius of the Chinese language and beyond its capabilities.

IN the course of the discussion, some interesting facts with regard to the translation of scientific terminology into Chinese were mentioned. Dr. Martin, of Pekin, referred to Ricci's old translation of Euclid, which he entitled "The Fundamental Principle of the Science of Quantity." Oxygen, hydrogen, and nitrogen are translated so as to express their characteristics of supporting life, of lightness, and of derivation from nitre. On the other hand, Dr. Macgowan mentions that a translator's difficulties in dealing with natural history terms are really enormous. He undertook the translation of Dana's "Mineralogy" and Lyell's "Elements of Geology" into Chinese for the Government, and a scientific native scholar was detailed to assist him. When they came to the plants that have the names of foreign botanists, most of them polysyllabic, they were appalled, and as they could only be rendered phonetically, the native scholar decided against translating any portion of the plant's name, transferring it bodily, according to sound, into Chinese. Similarly, the complex nomenclature of organic chemistry presents a formidable difficulty. A Chinese clergyman, who took part in the discussion, delivered a particularly interesting address, urging that the phonetic method should, as a rule, be employed, on the ground that the characters used in the translation of scientific terms have traditional meanings to the Chinese mind, and thus great confusion is created. The "term"-controversy which has agitated theologians in China for the past half-century, and has divided them into two hostile camps, appears likely to revive in the domain of science, the question lying between translation or phonetic reproduction.

FROM a study of thirty-two years' observations of thunderstorms in the Vienna region, Dr. Hann finds that there is a double maximum of frequency. The greatest number occur in the first half of June, the second smaller maximum is in the end of July; between these is a secondary minimum. (Thunderstorms hardly ever occur in winter.) This agrees with observations in Munich. In Brussels most thunderstorms occur in the second halves of June and July. The daily period in Vienna shows a chief maximum about 3.20 p.m., and a secondary one at 1.2 a.m. The spring and summer storms come mostly from the east or south-east, and seem to belong to Mediterranean

depressions, coming up from the Adriatic, as those of late summer seem to be on the south or south-east border of Atlantic depressions.

BETHNAL GREEN FREE LIBRARY has been doing a large amount of good work in the thickly-populated district in which it is situated, not only by giving facilities for reading books, but by science lectures and science "talks." It is much in want of funds for the extension of operations, and we commend it to the consideration of our readers. The librarian is G. F. Hilcken.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus sinicus*) from India, presented by Miss G. M. Fisher; a —— Hedgehog (*Erinaceus* ——) from Madras, presented by Mr. H. R. P. Carter; two Mute Swans (*Cygnus olor*), European, a Common Peafowl (*Pavo cristatus*) from India, presented by Lady Siemens; a Red and Yellow Macaw (*Ara chloroptera*) from South America, presented by Mr. Arthur Daunt; a Grey Parrot (*Psittacus erithacus*) from West Africa, presented by Mrs. Greenwood; five Great Eagle Owls (*Bubo maximus*), European, presented by Mr. Philip Crowley, F.Z.S.; a Common Guillemot *Lomvia troile*), British Islands, presented by Mr. J. H. Gurney, F.Z.S.; two Gambel's Partridges (*Callipepla gambelli*) from California, presented by Mr. W. A Conklin, C.M.Z.S.; a Malabar Green Bulbul (*Phyllornis aurifrons*) from India, received in exchange; five Great Titmice (*Parus major*), four Blue Titmice (*Parus cæruleus*), two Bullfinches (*Pyrrhula europæa*), European, purchased.

OUR ASTRONOMICAL COLUMN

THE ARGENTINE GENERAL CATALOGUE OF STARS.—This Catalogue, containing the mean positions of 32,448 southern stars determined at the National Observatory of Cordoba, has recently been published by Dr. Gould. The observations from which the Catalogue positions are deduced were made with the meridian-circle of the Cordoba Observatory during the years 1872–80. During these years the zone-observations were the chief object of attention, and the present Catalogue contains the places of those stars whose positions were more elaborately determined during the progress of that great work, and constitute an addition to our knowledge of southern stellar positions of perhaps not less importance than the Cordoba Zone-Catalogue. The General Catalogue gives the positions, for the epoch 1875·0, of most of the southern stars brighter than magnitude 8½, the deficiencies in this respect being chiefly found north of the parallel of 23°, at which the zones begin. These omissions will be of comparatively small importance, inasmuch as the new *Durchmusterung* of Prof. Schönfeld comprises all the southern stars within this region, while accurate determinations of the brighter ones will have been made in the re-observation of Lalande's stars now nearly completed at the Paris Observatory.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 DECEMBER 5–11

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on December 5

Sun rises, 7h. 51m.; souths, 11h. 50m. 51·4s.; sets, 15h. 50m.; decl. on meridian, 22° 25′ S.: Sidereal Time at Sunset, 20h. 47m.

Moon (two days after First Quarter) rises, 13h. 30m.; souths, 19h. 35m.; sets, 1h. 51m.*; decl. on meridian, 0° 19′ N.

Planet	Rises	Souths	Sets	Decl. on meridian
	h. m.	h. m.	h. m.	° ′
Mercury	7 16	11 32	15 48	19 53 S.
Venus	7 54	11 53	15 52	22 27 S.
Mars	10 19	14 10	18 1	23 45 S.
Jupiter	3 34	8 49	14 4	9 41 S.
Saturn	18 35*	2 38	10 41	21 29 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Occultations of Stars by the Moon (visible at Greenwich)

Dec.	Star	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image
			h. m.	h. m.	° °
5	14 Ceti	6½	16 52	near approach	358 —
10	48 Tauri	6	5 52	6 38	105 339
10	B.A.C. 1526	6	22 29	23 44	78 292

Saturn, December 5.—Outer major axis of outer ring = 45″·4; outer minor axis of outer ring = 17″·7; southern surface visible.

Variable Stars

Star	R.A.	Decl.		
	h. m.	° ′		h. m.
U Cephei	0 52·2	81 16 N.	Dec.	8, 1 46 *m*
Algol	3 0·8	40 31 N.	,,	6, 23 15 *m*
			,,	9, 20 5 *m*
ζ Geminorum	6 57·4	20 44 N.	,,	9, 5 0 *m*
V Geminorum	7 16·8	13 19 N.	,,	7, *M*
U Coronæ	15 13·6	32 4 N.	,,	7, 0 32 *m*
β Lyræ	18 45·9	33 14 N.	,,	11, 19 0 *M*
S Vulpeculæ	19 43·7	27 0 N.	,,	6, *m*
T Aquarii	20 43·9	5 34 S.	,,	5, *M*
δ Cephei	22 24·9	57 50 N.	,,	7, 0 0 *M*
			,,	10, 19 0 *m*

M signifies maximum; *m* minimum.

Meteor-Showers

The principal shower of the week is that of the *Geminids*; R.A. 105°, Decl. 32° N., but moonlight will interfere with its observation at the time of its maximum, December 10–11.

Stars with Remarkable Spectra

Star	R.A. 1886·0	Decl. 1886·0	Type of spectrum
	h. m. s.	° ′	
20 Leporis	5 6 3	11 59·4 S.	III.
119 Tauri	5 25 32	18 30·5 N.	III.
64*a* Schjellerup	5 38 52	20 38·8 N.	IV.
α Orionis	5 48 59	7 23·1 N.	III.
π Aurigæ	5 51 27	45 55·5 N.	III.

THE ROYAL SOCIETY[1]

FOR many years it has been my duty as senior secretary to read at each anniversary the death-roll of the year. The names this year are perhaps slightly fewer than usual, but many recall to us faces once familiar that we shall never see here again. Earliest among them comes Sir Frederick Evans, whose death took place only very shortly after our last anniversary. In the course of the preceding summer he crossed the Atlantic to take part in that International Conference which assembled at Washington, to deliberate among other things on the choice of a common prime meridian for all civilised nations. On his return he was looking ill, and the illness increased until it carried him away. Yet even through his illness he kept on working at science, at a task he had undertaken, and which was almost completed when he died. To this I shall have occasion to refer again. In Mr. Busk we have lost one who has long been among us, and who took an active part in the scientific business of the Society. He repeatedly served on our Council, and both then and subsequently gave us the benefit of his extensive knowledge and sound judgment in the important but laborious task of advising the Committee of Papers as to the proper mode of dealing with papers which they referred to him. In Lord Cardwell we have lost a statesman whose political duties did not prevent him from coming among us and serving on our Council. The public services and singular honesty and straightforwardness of Mr. Forster are appreciated by the nation at large. Quite recently, at no advanced age, we have lost Prof. Guthrie, the occupant of a chair which a great many years ago I held for a time; a man whose genial character drew around him a close circle of friends. Still more recently we have lost the Earl of Enniskillen, whose fine palæontological collections are well known to geologists. Only the other day one passed away whom we seldom missed at our anniversary meeting, and who was frequently with us on other occasions: I allude to General Boileau, whose philanthropic labours will not soon be forgotten, and may, I trust, be recognised in a much needed form.

The Fellows will have noticed with satisfaction a very con-

[1] Anniversary Address by Prof. G. G. Stokes, President, on Tuesday, November 30, 1886.

siderable excess of income over expenditure in the balance sheet for the year. At first sight it might be supposed that as the *Transactions* come out at irregular intervals there might have been fewer parts published than usual; but it will be found on examination that the past year has borne its proper share of printing expenses. The excess is really due to a substantial improvement in the Society's property, under the careful and judicious management of our Treasurer.

Last year our President informed the Fellows of the munificent offer made to the Society by Sir William Armstrong to give to the Scientific Relief Fund the sum of 6500*l*., provided an equal sum were raised by subscription from the Fellows, and, if need be, other friends of science who might not belong to the Society. As the Fellows are aware, a circular was sent round by the Treasurer mentioning Sir William Armstrong's generous offer, and inviting subscriptions; and the Treasurer has also written privately to a number of persons, Fellows and others. The sum subscribed or promised in response to this invitation amounts to about 4200*l*.; and though the sum thus raised does not amount to what Sir William promised to duplicate if it could be raised, he has most generously not only waived the non-fulfilment of the condition subject to which the former offer was made, but has still further augmented it; and he now promises not only to duplicate the sum raised in answer to the Treasurer's appeal, but to give the further sum of 3600*l*., thus raising the capital from the present sum of about 8000*l*. to 20,000*l*. He will be ready to pay the whole sum of 7800*l*. as soon as the subscriptions promised to the Treasurer have been collected. The only condition attached to this princely gift is, that, besides meeting the ordinary objects for which the Fund was instituted, the Council should feel themselves at liberty to apply a portion of the income to defraying the annual subscriptions of Fellows in special cases where such a course might seem desirable.

The path of the total eclipse of September 9 of last year, in any place where it fell on land, was so remote from this country that no expedition went out to observe it. It was visible in New Zealand, and in anticipation of it our Eclipse Committee sent out a memorandum to the colony indicating the points of special interest to look out for. We have received accounts, drawings, and photographs of the eclipse from Dr. Hector and others. One of the most remarkable features of this particular eclipse was the appearance of two white and unusually bright prominences which attracted general notice, and were compared to electric lamps, and which, situated on opposite sides of the sun, were just over the places of two large spots, one close to the limb, and on the point of disappearing, the other not seen before the eclipse but visible next day, having in the meantime come round the limb.

The present year afforded another of those rather rare occasions, always of brief duration, which are afforded for the study of solar physics by a total eclipse of the sun. Calculations made long beforehand showed that a total eclipse was to be expected on August 29. The path of the total phase on the earth's surface is always narrow, say 100 miles or so across, and on this occasion it swept obliquely across the Atlantic Ocean, cutting the Western Coast of Africa about Benguela, and sweeping across some of the West India Islands to a part of the mainland of South America, where it ended.

Though there was a long belt of ocean over which the totality would be visible, and where the imposing spectacle of a total eclipse might be witnessed, this was not available for regular scientific observations, which require land on which to fix the instruments. On the mainland of America the total phase would come on so shortly after sunrise that the sun would be too low for good observations, and therefore the Island of Grenada, which lay within the belt of totality, was much to be preferred.

Of the two available stations, one lay in the British dominions, and was pretty easy of access from England, and accordingly it seemed to be the duty of our country to take a foremost place in the observations, the results of which would be available to the whole scientific world. It was contemplated first to send expeditions to both places—to Benguela as well as Grenada. The cost of this would, however, exceed what could be spared from the Government Grant without unduly curtailing what was available for other objects. Accordingly application was made to the Lords of the Treasury for a grant of 1000*l*. towards the cost of the expeditions. Inquiries were also made as to the probable climate at the two places; and here I have to express our thanks to the Governor-General of the Windward Islands, who put us in communication with Dr. Wells of Grenada, from whom we obtained valuable information regarding the climate of that island, and to the Consul-General for Portugal, who obtained information for us from the Polytechnic Institution at Lisbon as to the amount of sunshine about the end of August at Loanda, which may be taken pretty well as representing Benguela.

The information we obtained from various sources as to Benguela was rather conflicting, but there seemed a pretty general agreement that even if the sun should be shining at the time of the eclipse the sky was likely to be hazy. This would much interfere with good observations, especially as regards the corona; and as the expense of the expedition to Benguela would be considerable, and the success very doubtful, we thought it better to give up that part of the project and confine ourselves to Grenada. Being anxious to trench as little as possible on the national expenditure, and finding that a little more could be taken from the Government Grant than we had expected, we wrote to the Treasury reducing our application to 500*l*., which, with assistance from the Admiralty in the shape of the use of a ship-of-war on the West India station, and supplemented by some money from the Government Grant and from our own Donation Fund, might enable us to meet the expenditure.

The result was that a sum not exceeding 500*l*., to supplement what could be spared from the Government Grant, was granted, and the expedition, as the Fellows are aware, has sailed and returned. It was fairly successful, the observations having been prevented by clouds at only one of the stations occupied.

There has not yet been time to discuss the observations in full, but two points already appear to have come out pretty clearly. One is that the brightness of the corona, which on this occasion was actually measured, was much less than had been expected, and less apparently than it had been on former occasions. This seems to show that the brightness is liable to great changes in comparing different years, as we know is the case with the form. The other point touches on the question of the possibility of photographing the corona independently of an eclipse. If the photographic brightness of the corona be not overpowered by that of the atmospheric glare immediately around the sun when there is no eclipse, then when the sun is partially eclipsed we might expect to be able to trace the outline of the limb of the moon for some way outside the sun, since the moon would be projected on the background of the corona. The experiment was tried both by Capt. Darwin at Grenada, and by Dr. Gill at the Cape, but in neither case was the limb traceable outside the sun. This throws doubt on, but does not disprove, the validity of the method; for Dr. Huggins himself has never obtained photographic appearances apparently referable to the corona since the Krakatão eruption. It may be that the finely suspended particles, whether connected with the Krakatão eruption or not, which produced those gorgeous sunsets that were so remarkable, have not yet wholly subsided, and cause a considerably increased atmospheric glare. It may be that the corona has actually been much less bright than usual for the last few years.

The present year has been signalised by that remarkable volcanic explosion in New Zealand, of which we have read accounts in the newspapers. We have received from Dr. Hector a series of photographs of the district, taken at no great length of time after the explosion.

The Krakatão Committee, which was appointed at the suggestion of our late President to collect information relative to the great eruption, have now I may say completed their work. The Royal Meteorological Society had appointed a Committee to get together information respecting the remarkable atmospheric phenomena witnessed after the eruption. It was thought desirable that the two Committees should work in concert, and accordingly our Committee was enlarged by the addition of two members of the Royal Meteorological Society, even though they did not happen to be members of the Royal Society, who undertook that share of the work. The information collected under this head is naturally voluminous, since it requires no special training to describe the atmospheric appearances. Our late Fellow, Sir Frederick Evans, undertook the sea-disturbance, and continued to work at it even in an advanced stage of the disease which carried him off. Another fortnight, it was estimated, would have enabled him to complete it. His account was found to have been written in pencil on separate sheets of note-paper, but his successor in the office of Hydrographer, Captain Wharton, our Fellow, was so good as to take up the work; and partly by the use of materials left by Sir F. Evans, partly by his own independent labour, he has now completed it. The report on air-

disturbance was undertaken by General Strachey, and is ready. Prof. Judd undertook geology; the materials are ready, and though the actual report is not yet written, the writing would take but very little time. Mr. Scott undertook to collect information as to floating pumice; but as it has been found that the Krakatão pumice does not possess distinctive features whereby it could be recognised, and therefore the origin of the pumice that ships have encountered at a distance from Krakatão remains unknown, little trustworthy information could be obtained under this head, and the report has been handed over to Prof. Judd to embody with the geology. The heaviest part of the report, that relating to sunsets and atmospheric phenomena, has been prepared by the Hon. Rollo Russell and Prof. Archibald, the two Fellows of the Royal Meteorological Society who have been mentioned as having been added to the Committee, and is ready, with the exception of a little revision, and it remains only to prepare an introduction, index, &c. The whole report may therefore be regarded as all but complete in manuscript, and it will be for the new Council to deal with it.

The Circumpolar Committee have now brought their labours to a close, the report on the observations taken by Capt. Dawson at Fort Rae being printed and published. The reports of the expeditions undertaken by Austria, the United States of America, Germany, and Holland are, I understand, complete, and those by France and Russia are in a forward state. Before the accounts of the observations taken at different stations by the observers of different nations shall have been for some time before the public, it would be premature to expect general conclusions to be deduced from this great undertaking.

Very satisfactory progress has been made during the past year with the publication of the Report of the *Challenger* Expedition. The volumes already published and in the Society's Library now amount to sixteen on Zoology, and three introductory on other subjects. Others are in a very forward state, and it is expected that the whole will be published very nearly within the time mentioned by the Committee, probably at the end of the next financial year.

As mentioned in the Presidential Address last year, advantage has been taken of the British occupation of Egypt to make some explorations by way of boring in the Delta of the Nile, to the results of which geologists attach great importance. The War Department has allowed some of the staff of the Royal Engineers, when their services were not otherwise required, to take part in the operations, and has lent the boring apparatus, and the Royal Society voted the sum of 350*l.* out of its own Donation Fund to defray the cost of labour and other incidental expenses. It was contemplated originally to make a chain of borings, but the depth to which it has been found necessary to proceed in order to get through the ordinary deposit has turned out to be so great that it was thought better, instead of attempting many, to try and get if possible down to rock, or to something else which might afford evidence that what could be referred to alluvium from the Nile or drifted sand had really been got through. A deep boring has accordingly been made at Zagazig, under the direction of Capt. Dickenson, R.E. This has now been carried to a depth of 190 feet 6 inches below the surface, or 164 feet 5 inches below the mean sea-level at Alexandria, and yet nothing has been reached but sand and clay with small pebbles. Prof. Judd is now engaged in the examination of the matter brought up. A derangement of the boring apparatus prevented for the present further progress, and the use of a narrower pipe than any at hand would be required for carrying the boring deeper. The Committee considered that it would be more important to extend this boring, so as if possible to get down to rock, or else to Miocene fossils, than to make a fresh boring in a different place, and arrangements are being made accordingly. The inquiry was deemed a proper one to be assisted out of the Government Grant, and the sum of 200*l.* has been voted from this source to supplement the Royal Society's grant already mentioned.

The ordinary meetings of the Society are well known, and are frequently attended by strangers by permission of the Fellows present; and the papers brought before us are known to the world through our publications. But a great deal of scientific work is done of which the outside public knows nothing. There have been thirteen meetings of the Council during the year, and the attendance at our council meetings is remarkably good. There have been more than seventy meetings of committees and sub-committees.

There is further another task on which a great deal of gratuitous and conscientious labour of the highest kind is bestowed. I allude to the examination of papers with a view to advising the Committee of Papers as to their publication. The past year has shown no flagging in scientific activity in relation to papers brought before us.

The preparation of the manuscript for another decade, 1874 to 1883, of the Royal Society's catalogue of scientific papers, is now almost complete. This great work has been extremely useful to men of science in enabling them at once to find where a memoir on a particular subject, written by an author whose name they know, as is usually the case, is to be found. To some extent it enables them also to find what has been written on a particular subject, for there are usually one or two authors, whose names they know, who have made it a special study, and on consulting their papers references are frequently found to the writings of others who have written on the same subject. Nevertheless, it must be confessed that the value of the catalogue would be greatly increased if it could be accompanied by a key, of the nature of an *index rerum*. It was originally contemplated that this should be added, but the magnitude of the undertaking has hitherto prevented the Committee from attempting it. To be well done it would require the long-continued labour of a scientific staff representing different branches of science, and they could not be expected to engage in so heavy a work without adequate remuneration.

A great deal of work has been done during the past year in relation to the library. More than 5000 volumes have been removed to other rooms to make space for the more important works constantly accruing. A list of duplicates and deficiencies has been printed and circulated among corresponding societies. A shelf catalogue is in progress, and is about a third of the way towards completion. Some work has also been done upon a catalogue of miscellaneous literature.

The electric lighting of the Society's apartments, which is now complete, seems to have given general satisfaction.

On August 31 of this year, our distinguished Foreign Member, M. Chevreul, attained his hundredth year. Rarely indeed is it given to any one to see right through a century, more rarely still to retain his powers to such an age, yet both, I am happy to say, have been granted to M. Chevreul. In anticipation of this event, preparations were made for its due celebration. I received an invitation for our Fellows to assist at the celebration; but unfortunately it was at a time of year when most of us were scattered, and moreover time did not permit of making it generally known. I am afraid we had no representative at the actual ceremonial, but I am sure that none the less our hearts were with the veteran *savant*.

This year has also witnessed the celebration of the 250th anniversary of the University of Heidelberg. The Council had appointed our Foreign Secretary as a deputation to represent the Society on the occasion. Unfortunately when the time was close at hand, Dr. Williamson was prevented by the condition of his health from taking part in the celebration; but acting on the emergency on behalf of the Society, I requested our Fellow, Sir Henry Roscoe, to take his place, which he was so good as to do.

In his Presidential Address last year, Prof. Huxley suggested the idea, I may say expressed the hope, that the Royal Society might associate itself in some special way with all English-speaking men of science; that it might recognise their work in other ways than those afforded by the rare opportunities of election to our foreign membership, or the award of those medals which are open to persons of all nationalities alike. This suggestion has been taken up in one of our colonies. We have received a letter from the Royal Society of Victoria, referring to this passage in the Address, and expressing a hope that in some way means might be found for establishing some kind of connection between our own oldest scientific Society and those of the colonies.

The Council have appointed a Committee to take this letter into consideration, and try if they could devise some suitable plan for carrying out the object sought. The Committee endeavoured at first to frame a scheme which should not be confined to the colonies and dependencies of the British Empire, but should embrace all English-speaking communities. But closely connected as we are with the United States by blood and language, they are of course politically a foreign nation, and this fact threw difficulties in the way of framing at once a more extended scheme, so that the Committee confined themselves to the colonies and dependencies of our own country, leaving the wider object for

some future endeavour, should the country concerned seem to desire it. The scheme suggested was laid before the members of the present Council, but there was not an adequate opportunity of discussing it, and it will of course come before the new Council. Should they approve of some such measures as those recommended by the Committee, they will doubtless assure themselves in some way or other that those measures are in accordance with the wishes of the Fellows at large before they are incorporated into the Statutes.

But in connection with this subject there is another suggestion which I would venture to offer, and which I know has been thought of by others.

A good many years ago it was not unusual to elect to the Fellowship men of distinguished eminence in departments other than scientific. More recently a change was made in the Statutes whereby Privy Councillors are enabled to become Fellows by a special method, without interfering with the selection by the Council of fifteen from among the candidates whom they recommend to the Society for election. This to a certain extent superseded the necessity of appealing to other than scientific claims, and in some respects the method had special advantages. Those who attained to a place on Her Majesty's Privy Council were sure to be distinguished men, whom we should be glad to welcome among us; and by confining the privilege of special election to these, with whose appointment the Council had nothing to do, all invidious distinctions were prevented. But the method has the disadvantage that it applies only to a particular class of merit. A man, for instance, might be of quite first-rate eminence in poetry or literature, but that would not lead to a seat on the Privy Council. Such a man could only be elected by being placed on the selected list of fifteen. But it seems to me that there is something not quite courteous either to the eminent man himself, or to the scientific man who would have to be passed over to make room for him, in thus putting him in competition with those who seek admission on purely scientific grounds. I cannot help thinking that it might be well if the Council had the power of recommending for special election men of high distinction on other than scientific grounds, whose connection with us would on both sides be felt to be an honour, and who, though not, it may be, themselves scientific, might usefully assist us by their counsel. I do not think it would be difficult to devise means for providing that such a privilege should be accorded only in case of very high eminence.

The application of photography to the delineation of celestial objects has of late years made rapid strides; and, partly owing to the improved sensitiveness of the plates, partly to greater exactness in regulating the motions of equatorially-mounted telescopes, it has been found possible to photograph even minute stars. The question is accordingly now seriously entertained whether we may not trust to photography for the formation of star maps and star catalogues, taking eye-observations on a sufficient number of stars here and there for reference, and trusting to differential measurements taken on the plates for determining the positions of the other stars. Indeed, I think the practicability of this application may now be considered as established, and there only remains the question of the best mode of carrying it out on a uniform plan. In the course of the autumn I had a letter from Admiral Mouchez, Director of the Paris Observatory, in which he informed me that in response to the presentation of specimens of the admirable star photographs taken by the MM. Henry, several of the astronomers to whom they had been sent suggested that it would be well that a conference of astronomers of various nations should be held, with a view to taking concerted action for obtaining on a uniform plan a complete map of the whole starry heavens. He wished accordingly to obtain an expression of opinion on the part of the Royal Society as to the desirableness of holding such a conference; and as it was contemplated, in case the proposal should be favourably entertained by those consulted, that the conference should be held at Paris in the spring, and it would be necessary to give timely notice to the astronomers who live in the southern hemisphere, an early reply was requested.

As it would have defeated Admiral Mouchez's object to wait till the Council should re-assemble after the recess, I wrote at once to consult four of our Fellows specially named by Admiral Mouchez; and on receiving their replies I wrote to Admiral Mouchez, saying that under the circumstances I took it upon me to express in the name of the Royal Society our approval of the suggestion, explaining at the same time that I did so on the understanding, which I fully believed to be in accordance with his intention, that the astronomers who might attend the conference should not be considered as pledged to the adoption of the methods or scale of the MM. Henry, but that the whole subject should be open to discussion. On reporting what I had done to the Council when they met after the recess, I obtained an expression of their approval.

In these photographs a remarkable instance was exhibited of the power of photography to reveal the existence of objects wholly invisible to the eye. One of the stars of the Pleiades was found to be surrounded by a nebula which cannot be seen with telescopes. The reason of the difference of power of the plate and eye is very obvious: with the eye an object is either seen or not seen at once, whereas with the plate, provided there be an absence of stray light, feebleness of intensity can be made up for by length of exposure.

But the MM. Henry are by no means the only persons who have applied photography to the delineation of the stars. Among others, our Fellow, Dr. Gill, who has sent us some excellent specimens of the photographs obtained by his instrument, proposes to take at the Cape Observatory photographs of the whole starry heavens of the southern hemisphere, under such conditions as to include the magnitudes contained in Argelander's "Durchmusterung" of the northern hemisphere, and to subsequently reduce the observations so as to complete Argelander's great work by extending it to the southern hemisphere. Prof. Kapteyn, in Holland, has nobly undertaken to devote his spare time for seven years to superintending the reduction. Dr. Gill has laid the proposal before the Government Grant Committee. Having regard to the magnitude of the undertaking, and the probability of a conference of astronomers being shortly held in Paris to discuss the whole question, the Government Grant Committee suggested to the Council of the Royal Society that they should appoint a committee to take the subject into consideration, and the Council have acted on this suggestion. Dr. Gill intends to come to Europe in the spring, so that the committee will be able to consult him personally.

This morning I received through the Foreign Office an invitation from the Académie des Sciences for myself and some other delegate of the Royal Society to attend the conference to which I have already referred, which is fixed for April 16. I shall take the first opportunity of consulting the new Council as to their wishes.

The Copley Medal for this year has been awarded to the veteran in science, our Foreign Member, Prof. Franz Ernst Neumann, for his researches in theoretical optics and electro-dynamics.

Having in his earlier years treated of crystallographic subjects almost half a century ago, he turned his attention to the theory of light. Fresnel had, with his wonderful sagacity, arrived at his celebrated laws of double refraction from the theory of transverse vibrations, aided by conceptions derived from a dynamical theory which was only in part rigorous. Cauchy and Neumann, independently of each other, were the first to deduce from a rigorous dynamical calculation, applied to a particular hypothesis as to the constitution of the ether, laws of double refraction, not indeed absolutely identical with those of Fresnel, but closely resembling them. In this case the laws were known beforehand. But in a very elaborate later paper, Prof. Neumann deduced from theory the laws of crystalline reflection, laws which appear to agree with the observations of Seebeck, and which had not been discovered by Fresnel, though some of them were independently and about simultaneously obtained by MacCullagh.

Prof. Neumann is perhaps still better known in connection with the theory of electro-dynamics, and the mathematical deduction of the laws of induced currents due to the motion of the primary and secondary conductor. He may be said to have completed for the induction of currents the mathematical treatment which Ampère had applied to their mechanical action.

Of the two Royal Medals, it is the usual, though not invariable, practice to award one for the mathematical and physical, and the other for the biological sciences.

One of these medals has this year been awarded to Prof. Peter Guthrie Tait, for his various mathematical and physical researches.

Prof. Tait is well known for his numerous and important papers in both pure mathemathics and physics. The late Sir William Hamilton regarded him as his own successor in carrying on and completing the newly-invented calculus of quaternions, of which Prof. Tait is continually making new applications. Among his investigations in the domain of experimental physics

may be mentioned his determination of the conducting powers of metals for heat by a method which appears to possess special advantages, and his investigation of the effect of extremely great pressures on thermometers, undertaken with a view to deducing correct results for the temperatures at great depths in the ocean from the observations made in the *Challenger* expedition. This latter subject has led him to investigate the behaviour, as to compressibility and development of heat, of liquids and solids under enormous pressures, a subject in which he is still engaged. Before concluding, I must mention his elaborate papers on systems of knots, recently printed in the *Transactions* of the Royal Society of Edinburgh.

The other Royal Medal has been awarded to our Fellow, Mr. Francis Galton, for his statistical inquiries into biological phenomena.

Mr. Galton is well known as an explorer and geographer, and his mind is singularly fertile in the devising of ingenious instruments for various objects. Many years ago he brought before us some remarkable experiments instituted with a view to test a particular biological theory, in which rabbits of a pure variety were so connected with others of a different variety that the same blood circulated through both individuals, and the point to determine was whether this blood-relationship, in the most literal sense of the term, had any effect on the offspring. Contrary to what the theory in question led us to regard as the more probable, the result proved to be negative. It is, however, in accordance with the rules for the award of the Royal Medals, more especially the later investigations of Mr. Galton, in relation to vital statistics, that have been taken as the ground of the award. He has shown that by taking the average of a number of individuals having some condition in common, individual peculiarities apart from that condition are eliminated in the mean, and results are obtained which may be regarded as typical of that condition. One way of doing this is by his method of compound photographs. Thus we may obtain typical features of criminals of a particular kind, of consumptive persons, and so forth. By adhering to the method of averages, he has even succeeded in obtaining a mathematical expression, very closely verified in observation, connecting the mean deviation of some condition (such for example as stature) in a series of individuals, from the general mean of the same condition, with the mean deviations of the same condition in the relatives of those same individuals of different kinds, such as fathers, brothers, &c. Nor is the statistical method applicable to bodily characteristics alone. Mr. Galton has even extended it with remarkable ingenuity and originality to mental phenomena also.

The Rumford Medal has been awarded to Prof. Samuel P. Langley, for his researches on the spectrum by means of the bolometer.

A better knowledge of the ultra-red region of the spectrum, which includes the larger part of the energy of solar radiation, had long been a desideratum when Prof. Langley commenced his work upon this subject. Finding the thermopile insufficiently sensitive for his purpose, he contrived the "bolometer." This instrument depends upon the effect of temperature upon the electrical resistance of metals, a quantity susceptible of very accurate measurement; and, with its aid, Prof. Langley has been able to explore a part of the spectrum previously almost inaccessible to observation.

A result of Prof. Langley's work, very important from the point of view of optical theory and of the ultimate constitution of matter, relates to the law of dispersion, or the dependence of refrangibility on wave-length. Cauchy's formula, which corresponds well with observation over most of the visible spectrum, is found to break down entirely when applied to the extreme ultra-red.

Prof. Langley has given much attention to the important question of the influence of the atmosphere on solar radiation. The expedition to Mount Whitney, successfully conducted by him in face of many difficulties, has given results of the utmost value, pointing to conclusions of great interest and novelty.

The Davy Medal has been awarded to our Foreign Member, M. Jean Charles Galissard de Marignac, for his researches on atomic weights.

M. Marignac's numerous researches on atomic weights, which have been continued for a great number of years, have played an exceedingly important part in establishing and consolidating that ground-work of chemistry. They are remarkable for originality in devising methods appropriate to the respective cases, the most conscientious care in discovering errors which occurred in the respective operations, and indefatigable perseverance in finding means to eliminate the disturbing influences. His labours are all the more valuable because he chose for their field chiefly those elements which are most generally used in chemistry, and are most important to chemists, and on which the determination of new atomic weights is most generally made to depend.

TEN YEARS' PROGRESS IN ASTRONOMY[1]

III.

COMETS.—During the past ten years we have been favoured with an extraordinary number of comets, and while perhaps no single great step has been made, yet it is certain, I think, that our knowledge of these mysterious objects has gained a real and considerable advance.

In 1876, curiously enough, not a single comet appeared; but in 1877 there were 6; in 1878, 3; in 1879, 5; in 18 0, 5; in 1881, 8; in 1882, 3; in 1883, 2; in 1884, 3; and in 1885, 6; and so far this year, 3. Forty-four comets in all have been observed during the ten years, six of which were conspicuous objects to the naked eye, and two of them, the great comet of 1881, and the still greater one of 1882, were very remarkable ones.

The first of these will always be memorable as the first comet ever photographed. Dr. Henry Draper photographed both the comet itself and its spectrum; Janssen obtained a picture of the comet, and Huggins of its spectrum.

A number of excellent photographs were obtained of the great comet of 1882, especially by Gill, at the Cape. And it is worth mentioning that in May 1882 a little comet (not included in the preceding list, because no observations were obtained of it) was caught upon the photographs of the Egyptian eclipse.

Two of the bright comets, Wells's comet of 1881 and the great comet of 1882, approached very close to the sun, and their spectra, as a consequence, became very complex and interesting. A great number of bright lines made their appearance. Sodium was readily and certainly recognised; iron and calcium probably, but not so surely. The evidence as to the nature of the sun's corona, derived from the swift passage of the 1881 comet through the coronal regions, has already been alluded to.

The Pons-Brooks comet of 1883-84 is extremely interesting as presenting the first instance (excepting Halley's comet, of course) of one of the Neptunian family of comets returning to perihelion. There are six of these bodies with periods ranging from sixty-eight to seventy years. Halley's comet, the only large one of the group, has made many returns, and is due in 1910. Pons's comet, first observed in 1812, has now returned; Olbers's comet of 1815 is due in 1889, and the three others, all of them small, in 1919-20 and 1922.

I have spoken of them as Neptunian comets, *i.e.* their presence in our system is known to be due in some way to this planet. The now generally received theory is that they have had their orbits changed from parabolas into their present shape by the disturbing action of Neptune. Mr. Proctor has pointed out certain unquestionable, though, I think, inconclusive, objections to this view, and he proposes, as an alternative, the startling and apparently improbable hypothesis, that they have been *ejected* from the planet at some past time by something like volcanic action.

On the whole, however, the most important work relating to comets has been that of the Russian astronomer Bredichin. He has brought the mechanical and mathematical portion of the theory of comet's tails to a high degree of perfection; following out the lines laid down by Bessel, but improving and correcting Bessel's formulæ, and determining their constants by a most thorough discussion of all the accurate observations available.

It is hardly possible to doubt any longer that all the facts can be represented on the hypothesis that the tails are composed of minute particles of matter, first driven off by the comet, and then repelled by the sun. Bredichin's most interesting result, arrived at in 1878, is that the tails appear to be of three, and only three, distinct types—the long straight streamers which are due to a repulsive acceleration about twelve times as great as the sun's attraction; the second and most ordinary class of broad-curved tails for which the repulsive force ranges between one and two and a half times that of the attraction; and, finally, the short,

[1] "Ten Years' Progress in Astronomy, 1876-86," by Prof. C. A. Young. Read May 17, 1886, before the New York Academy of Sciences. Continued from p. 98.

stubby brushes which are found in a few cases, and correspond to a repulsive force not more than one-fourth the sun's attraction. Supposing, as he does, that the *real* repulsion is the same for each atom, the *apparent* repulsion, or repulsive *acceleration*, would be greater for the lighter atoms, and nearly inversely proportional to their molecular weights; and so he concludes that probably tails of the first type are composed of hydrogen, those of the second type of hydrocarbons, like coal-gas, and those of the third of iron, and its kindred metals. As to the second type, the spectroscope speaks distinctly in confirmation. Tails of the first and third types are not common, and are usually faint, and since Bredichin's result was announced there has been no opportunity for spectroscopic verification in their case.

I said his investigations had given a mathematical and mechanical explanation of comets' tails; but the *physical* question, as to the nature of the force which causes the observed repulsion, remains unsettled, though I think there is no doubt that general opinion is crystallising into a settled belief that it is electrical; that the sun is not at the same electric potential as surrounding space, and that, in consequence, semi-conducting masses of pulverulent matter, such as comets seem to be, are subject to powerful electric forces as they approach and recede from the central body. At the same time there are those—Mr. Ranyard, for instance—who forcibly urge that the direct action of the solar *heat* might produce a similar repulsive effect by causing rapid evaporation from the front surface of minute particles, charged with gases and vapours, *frozen* by the cold of outer space.

I ought not to dismiss the subject of comets without at least alluding to the numerous unprecedented and interesting phenomena presented by the great comet of 1882: first, its unquestionable relation to, but distinctness from, its predecessors of 1880, 1843, and 1668, the three belonging to one brotherhood, of common origin, and all following nearly the same path around the sun. I call special attention to this point, because Miss Clerke, in her new and admirable "History of Astronomy in the Nineteenth Century" (which I hope every one interested in astronomy will read as soon as may be), has, I think, made a mistake regarding it, assigning to the difference between the computed periods of these comets much too great an importance.

The strange elongation of the nucleus of this comet into a string of luminous pearls; the faint straight-edged beam of light that enveloped and accompanied the comet for some time; and the several detached wisps of attendant nebulosity that were seen by several observers, are all important and novel items of cometary history.

Meteors.—Time will not allow any full discussion of the progress of meteoric astronomy. It must suffice to say that the whole course of things has been to give increased certainty to our newly-acquired knowledge of the connection between meteor-swarms and comets, and to make it more than probable that a meteor-swarm is the result of the disintegration and breaking-up of a comet. This seems to be the special lesson of the Bielids, the re-appearance of which, as a brilliant star-shower last November, attracted so much attention. In an important paper read before the National Academy of Sciences, last April, Prof. Newton pointed out how all the facts connected with the division into two of Biela's comet forty years ago, its subsequent movements and disappearance, and the meteoric showers of 1872 and 1885, and especially the peculiar features of this last shower, all conspire to enforce this doctrine.

I mention, doubtfully, in this same connection the recent supposed discovery by Denning of what are generally alluded to as "long radiants": systems of meteors, *i.e.*, which for weeks, and even months, together, seem nightly to emanate from the same point in the sky. One of these radiants, for instance, the first of half a dozen described by Mr. Denning, is about $1\frac{1}{2}°$ north of β Trianguli, and the shower appears to last from July to November, at the rate of perhaps one or two an hour.

If the fact is *real*, it follows inevitably that, disseminated through all the space in which the earth is moving, and has been moving for several years—not less than 1,000,000,000 miles—there are countless meteoroids moving in parallel lines, and with a velocity so great that the earth's orbital motion of 19 miles a second is absolutely insignificant as compared with theirs. Their speed must be many hundreds of miles per second. This may be true, but I own I am not ready to accept it yet. The observations indicate directly no extraordinary swiftness. Mr. Proctor, whose mind appears at present to be chiefly occupied by the idea that suns and planets are continually bombarding their neighbours (or at least do so at some stage of their existence), ascribes such meteors to the projectile energies of some of the "great" stars. But there is not time to discuss his notion, and it is hardly necessary, until it has begun to receive somewhat more extensive acceptance. I am not aware that, so far, he has any converts to his theory of comets and meteors.

Stars.—Want of time will also prevent any adequate treatment of the recent progress of stellar astronomy.

Two great works in the determination of star places must, however, be mentioned. One is the nearly completed catalogue of all the northern stars, down to the ninth magnitude, begun almost twenty years ago, under the auspices of the Astronomische Gesellschaft, by the co-operation of some fifteen different observatories. The observations are now nearly finished, and several of the observatories have already reduced and published their work. A very few years more ought to bring the undertaking to a successful end.

Another similar work, almost, though not quite, as extensive, is the great catalogue of southern stars, made at the Observatory of Cordova by our own Dr. Gould and his assistants. He himself, with his own eyes, observed every star of the whole number—nearly 80,000—his assistants reading the circle and making the records; and the whole has been reduced, printed, and published within the space of twelve years—a veritable labour of Hercules, for which, most justly, our National Academy has awarded him the Watson Medal. He had already, some years ago, received the gold medal of the English Royal Astronomical Society, for the "Uranometria Argentina," an enumeration of all the naked-eye stars of the southern hemisphere, with their approximate positions and estimated magnitudes. This, however, was only a sort of preliminary by-play, to pass the time while waiting for the completion of his observatory and meridian-circle.

We must mention also the remarkable star-charts made by Dr. Peters, of Hamilton College, of which he has already published and distributed at his own expense about twenty, and more are soon to follow.

But the old-fashioned way of cataloguing and charting the stars is obviously inadequate to the present needs of astronomy, and a new era has begun. While, hereafter, as hitherto, the principal stars, several hundred of them, will be observed even more assiduously and carefully than ever before, with the meridian-circle or similar instruments, the photographic plate will supersede the eye for all the rest. It is now easily possible to photograph stars down to the thirteenth or fourteenth magnitude, and to cover a space of $2\frac{1}{2}°$ square on a single plate. The remarkable thirteen-and-a-half-inch instrument constructed by the Henry Brothers, for the Paris Observatory, and first brought into use last August, does this perfectly. Instruments very similar, but smaller, lately set up at Harvard College, at the Cape of Good Hope, and at Liverpool, while they do not reach so faint stars, cover more ground at a time.

Negotiations are already under way to secure the co-operation of a number of observatories for a photographic survey of the heavens; and it is probable that, after some preliminary consultation and before very long, it will be actually in progress. According to Struve's estimates, it could be accomplished in about ten or twelve years, even on the Paris scale, by the combined efforts of fourteen or fifteen establishments. Orders have already been given to the Henry Brothers, by Dom Pedro, of Brazil, and Mr. Common, of England, for instruments precisely like the one at Paris. Americans, and New Yorkers especially, may well take a peculiar interest in astronomical photography, since it was at Cambridge, in 1861, that the first star-photographs were ever made, and here, in New York, Rutherfurd and Draper were among the earliest and most successful workers: in the observatory above us is now mounted the very instrument with which Rutherfurd made his unrivalled pictures of the moon and his plates of the Pleiades, more than twenty years ago.

During the past ten years, stellar photometry has become almost a new science. Its foundations, indeed, were laid by J. Herschel, Seidel, Wolff, and Zöllner, before 1870, and the magnitudes of some two hundred stars had been measured, and the law of atmospheric absorption determined. But the great work of Pickering, at Harvard, in the invention and perfecting of new instruments, and his "Harvard Photometry," which gives us a careful measurement of the brightness of all the naked-eye stars of the northern hemisphere, marks an epoch. And he is pushing on, and has already well under way the measurement of the 300,000 stars of Argelander's "Durchmusterung." Nor must we omit to mention Pritchard, of England, whose name has just been joined with Pickering's by the Royal Astronomical Society in the bestowal of their gold medal for his wedge-photometer and

the photometric work done with it. The "Harvard Photometry," and the "Uranometria Oxoniensis" together will carry down to all time the record of the present brightness of the stars. They will be especially valuable as data for determining changes in stellar brilliancy.

During the past ten years the number of variable stars has risen from about 100 to nearly 150; and our knowledge of their periods and light-curves has been greatly improved. In America, Chandler and Sawyer, of Boston, and Parkhurst, of this city, have done especially faithful work. During the ten years we have had two remarkable "temporary stars," as they are called—first the one which, in November 1876, in the constellation of Cygnus, blazed up from the ninth magnitude to the second, and then slowly faded back to its former brightness, but to a *nebulous* condition, as shown by its spectrum; then also the one which, last autumn, appeared in the heart of the nebula of Andromeda as of the sixth magnitude (where no star had ever been seen before), slowly dwindled away, and is now beyond the reach of any existing telescope. Perhaps, too, we ought to mention another little ninth-magnitude star in Orion's club, which last December rose to the sixth magnitude, and is now fading; it seems likely, however, from its spectrum, that this is only a new variable of long period.

As to star-spectra, a good deal of work has been done in their investigation with the ordinary stellar spectroscopes by the Greenwich Observatory, by Vogel at Potsdam, and by a number of other observers,—work well deserving extended notice if time permitted. But the application of photography to their study, first by Henry Draper in this city, and by Huggins in England, is the important new step. By the liberality of Mrs. Draper, and as a memorial of her husband, his work is to be carried on with the new photographic instrument and method just introduced by Prof. Pickering at Cambridge. He is able to obtain on a single plate the spectra of all the stars down to the eighth magnitude in the group of the Hyades, each spectrum showing under the microscope the characteristic lines quite sufficiently for classification. A different instrument is also to be built with the Draper Fund, which will give single star-spectra on a much larger scale and in fuller detail.

During the decade, the stellar parallax has been worked at by a number of observers. Old results have been confirmed or corrected, and the number of stars whose parallax is fairly determined has been more than doubled. The work of Brunnow and Ball in Ireland, of Gill and Elkins at the Cape of Good Hope, and of Hall, at Washington, deserves especial mention. A new heliometer of seven inches aperture has been ordered for the Cape Observatory, and when it is received, a vigorous attack is planned by co-operation between that observatory and that of Yale College, which possesses the only heliometer in America.

During the ten years, our knowledge of double stars has been greatly extended; several observers, and most eminent among them Burnham, of Chicago, have spent much time as hunters of these objects, and have bagged between one and two thousand of them. Several others, especially Doberck in England, and Flammarion in France, have devoted attention to the calculation of the orbits of the binaries, so that we have now probably about seventy-five fairly well defined.

In the study of the nebulæ, less has been done. Stephan at Marseilles and Swift at Rochester have discovered many new ones, mostly faint, and Dreyer, of Dublin, has published a supplementary catalogue, which brings Sir J. Herschel's invaluable catalogue pretty well down to date. The studies of Holden upon the great Orion nebula and the so-called "trifid nebula" deserve special mention, as securely establishing the fact that these objects are by no means changeless, even for so short a time as twenty or thirty years; also the discovery of a new nebula in the Pleiades by means of photography.

Observatories.—During the ten years, a considerable number of new observatories have been founded. Abroad, we mention as most important the observatories for astronomical physics at Potsdam, in Prussia, and at Meudon, in France, also the Bischoffsheim Observatory at Nice and its succursal in Algiers. The great observatory at Strasburg can hardly be said to have been founded within the period indicated, but the new buildings and new intruments and new efficiency date since 1880. We ought not to pass unnoticed the smaller observatory at Natal, in South Africa, and the private establishments of von Konkoly at O-Gyalla, of Gothard at Hereny (both in Hungary), and of the unpronounceable gentleman Jedrzejewicz at Plonsk, in Poland, and the observatory at Mount Etna, from which, however, we have no results as yet.

In the United States, we have the public observatories at Madison, Wis., at Rochester, N.Y., and at the University of Virginia, and the, as yet, unfinished Lick Observatory in California: also a host of minor observatories connected with institutions of learning, and mainly designed for purposes of instruction; such establishments have been founded within ten years at Princeton, at Northfield, Minn., at South Hadley, Ms., at Beloit, at Marietta, at Depauw, at Nashville, and at St. Louis, also at Franklin and Marshall College, and at Doane College, in Nebraska, at Columbia College, Ann Arbor, and Madison, Wis., and at one or two other institutions which escape me for the moment. Several others are also at this moment in process of erection. Every one of them has a telescope from six to thirteen inches aperture, with accessory apparatus sufficient, in the hands of an astronomer, for useful scientific work.

Instruments.—A large number of new instruments of great power have been constructed. We mention the great thirty-inch refractor of Pulkowa, the twenty-six-inch of Charlottesville, and the twenty-three inch at Princeton, for all which the lenses were made by our own Clark. We add the great Vienna twenty-seven-inch telescope by Grubb, and the twenty-nine-inch object-glass by the Henrys, made for the Nice Observatory, but not yet mounted; also the nineteen-inch telescope at Strasburg by Merz. Grubb has also at present a twenty-eight-inch object-glass under way for the Greenwich Observatory, and Clark has nearly completed the monstrous thirty-six-inch lens for the Lick Observatory. There never was a decade before when such an advance in optical power has been made.

Great *reflectors* have been scarce, the only ones of much importance constructed during the time being the twenty-inch instrument at Algiers, and Mr. Common's exquisite three-foot telescope, which he has lately sold to Mr. Crossley in order to make way for one of five feet diameter, now, I believe, under construction. The old three-foot and six-foot instruments of Lord Rosse have been improved in various ways, and are still in use,—especially in work upon lunar heat. Among newly-*invented* instruments, we mention the meridian-photometer of Pickering, the wedge-photometer of Pritchard, the almucantar of Chandler, the concave diffraction-grating of Rowland, and the bolometer of Langley—all, but one, American. Repsold's improvements in the micrometer, in the heliometer, and in the mounting of equatorials should also be mentioned here.

As to new astronomical methods, enough has been already said about photometry and astronomical photography. It is plain that we are entering upon a new era.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE examination for the Sheridan Muspratt Chemical Scholarship at University College, Liverpool, will begin on December 9. The Scholarship is of the value of 50*l.* per annum, tenable for two years. Candidates should apply to the Registrar before December 6.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, November 22.—M. Jurien de la Gravière, President, in the chair.—On the life and work of L. R. Tulasne, by M. Ed. Bornet. The paper contains a somewhat detailed account of the labours of this eminent botanist, who was born at Azay-le-Rideau (Indre-et-Loire) on September 12, 1815, and died on December 2, 1885. Appended is a list of the scientific publications of MM. Louis-René and Charles Tulasne.—On ammoniaco-magnesian phosphate, by M. Berthelot. In continuation of his previous researches on the colloidal and crystallised states of the earthy phosphates, and especially of the phosphate of magnesia, the author here studies the double ammoniaco-magnesian phosphate, determining the conditions of formation of this compound in chemical analysis.—The Montgaudier Cave, by M. Albert Gaudry. The author describes a visit he recently paid to this cave, which is situated in the Charente district, and which has revealed several objects of an artistic character, dating from the close of the Quaternary epoch, when the large fauna of extinct species had already mostly disappeared. But some remains,

such as pieces of ivory embellished with carvings of the aurochs and other animals, seem to have been executed at an earlier period, while the cave-dwellers were still struggling for existence with the mammoth, with *Rhinoceros tichorhinus*, the cave-bear, cave-lion, and large hyæna.—On glycose, glycogene, and glycogeny, in their relation to the production of heat and of mechanical labour in the animal system, by M. A. Chauveau. In this first physiological study of these elements, the author deals more especially with the generation of heat in the organism while in a state of repose. The reasons are set forth which lead to his broad generalisation regarding the preponderating part played by the glycose of the blood in organic combustions, source of animal heat and of muscular energy. It is now fully established that the absorption of glycose in the capillaries during the transformation of arterial into veinous blood is connected with the respective activity of the attendant combustions in the several organs.—Some remarks on the determination of mean values, by Leopold Kronecker. It is shown that in a converging series of real terms $\phi_1 + \phi_2 + \phi_3 + \ldots$ with positive real quantities $\psi_1, \psi_2, \psi_3 \ldots$ increasing with n beyond all limit, the limit of the expression—

$$\frac{1}{\psi_n}(\phi_1\psi_1 + \phi_2\psi_2 + \phi_3\psi_3 + \ldots + \phi_n\psi_n)$$

for increasing values of n is equal to zero.—On the movement of an indefinite and perfectly elastic fluid, by M. N. Marin. The object of this study is to complete the law of Mariotte by another described as the law of elasticity for perfectly elastic and completely free fluids. In a fluid so constituted, it is laid down that all contraction determined by any cause whatsoever acting in a single direction, is instantaneously propagated in all other directions.—On the movement of a cord in a fixed plane, by M. Appell.—On the algebraic integrals of Kummer's equation, by M. E. Goursat.—Analytical demonstration of a theorem relating to orthogonal surfaces, by M. Paul Adam. The theorem here dealt with is that of M. Maurice Lévy regarding a group of surfaces in an orthogonal system, and by him demonstrated on purely geometrical considerations.—On the unequal movement of a compressed gas in a reservoir freely discharging into the atmosphere, by M. Hugoniot.—On an apparatus by which the time may be communicated to the performers out of the conductor's sight, by M. J. Carpentier. The apparatus here described has been constructed at the request of the directors of the Paris Opera. It is based on the principle of visible signs, depending on a purely optical illusion, and producing the impression of an ordinary conductor's hand beating time. It is thus free from the defects inherent to the various electric appliances hitherto devised for the same purpose.—On a means of increasing the power of fluid and electric agencies, by M. Charles Cros. In this process a return is made to the old idea involved in the expression "electric fluid," and the wires are regarded as analogous to elongated tubes through which pressure is transmitted. The experiment was suggested by the author's researches on transmissions through more or less elastic tubes containing air or water.—On the tension of saturated vapour, by M. P. Duhem.—On the physical properties of mercury, by M. Marcellin Langlois. On the assumption of a mono-atomic molecule of mercury, the author determines its heat of evaporation, its specific heat, compressibility, and heat of fusion.—Actinometric studies, by M. E. Duclaux.—A new process of volumetric analysis for powdery zinc (*gris d'ardoise* of la Vieille Montagne), by M. Frédéric Weil. By the process here described, 100 gr. of this substance yield 65·3 gr. of pure zinc.—Action of the alcohols on the protochloride of gold and phosphorus, by M. L. Lindet. Here are described the preparation and properties of two chlauroso-phosphorous ethers—ethylic and methylic ether.—On the Russian petroleums, by M. J. A. Le Bel. The chief element of the petroleum of Baku, at the eastern extremity of the Caucasus, are naphthenes, C_nH_{2n}, and naphthylenes, C_nH_{2n-2}; and their salient characteristic is that they do not fix bromine.—On the heats of neutralisation of malic and citric acids and of their pyrogened derivatives: remarks on the numbers obtained, by MM. H. Gal and E. Werner.—On certain correlations between the modifications experienced by species of different genera subjected to the same influences, by M. Fontannes. Several analogous modifications are noted pervading many species of different genera throughout the geological record; but no theory is advanced to explain the coincidences.—On a new genus of parasitic Copepod, by M. Eugène Canu. This new genus is a parasite of the Synascidians, and abounds on the *Morchellium argus* (Milne-Edwards) frequenting the Wimereux district.—On the anomalous formations of the Menispermeæ, by M. Gérard.—Observations on the plaster added to new wines in the South of France and other parts of Europe, by M. A. Audoynaud.—Note on the coarse marine limestone formation of the Provins district (Seine-et-Marne), by M. Stanislas Meunier.—On the Devonian system of the Eastern Pyrenees range, by M. Ch. Depéret.—On the pleromorphoses of the quartz of Saint-Clément (Puy-de-Dôme), by M. Ferdinand Gonnard.—Description of a variety of Carphosiderite, by M. A. Lacroix. The optical properties of this mineral, which was found in the neighbourhood of Mâcon (Saône-et-Loire), are described.—On the conditions of form and density of the terrestrial crust, by M. A. de Lapparent. It is argued that the generally-accepted views regarding the symmetrical flattening of the globe at the poles is far from proved, and it is suggested that in the southern hemisphere there exists an inaccessible antarctic continent presenting a different conformation in this respect from that of the northern hemisphere.—On the mode of formation of the Newfoundland banks, by M. J. Thoulet.—On the progressive desiccation of lacustrine basins in dry climates, by M. Venukoff.

BOOKS AND PAMPHLETS RECEIVED

Die Schiffsmachine; Atlas: Bushey (Lipsius and Tischer, Kiel).—Second Armagh Catalogue of 3300 Stars: Robinson and Dreyer (Thom, Dublin).—An Arctic Province; Alaska and the Seal Islands: H. W. Elliot (Low).—Wild Animals Photographed and Described: J. F. Nott (Low).—Quarterly Journal of the Geological Society, vol. xlii. part 4, No. 168 (Longmans).—Studies from the Biological Laboratory, Johns Hopkins University, vol. iii. No. 8.—Calendar of University College of South Wales, 1886-87 (Owen, Cardiff).—Géologie de Jersey: Le P. C. Noury (Sary, Paris).—Memoirs of the Geological Survey of India—Palæontologia Indica, ser. x.; Indian Tertiary and Post-Tertiary Vertebrata, vol. iv. part 2, The Fauna of the Karnul Caves: R. Lydekker (Trübner).—Descriptive Catalogue of a Collection of the Economic Minerals of Canada: A. R. C. Selwyn (Alabaster).—L'Égalité des Sexes en Angleterre: F. Remo (Nouvelle Revue, Paris).—Theory of Magnetic Measurements: F. E. Nipher (Van Nostrand, New York).—Outlines of the Geology of Northumberland and Durham: G. A. Lebour (Lambert, Newcastle-on-Tyne).—Lehrbuch der Histologie: Dr. P. Stohr (Fischer, Jena).—Lehrbuch der Entwicklungsgeschichte, Erste Abth.: Dr. O. Hertwig (Fischer, Jena).—Lunar Science, Ancient and Modern: Rev. T. Harley (Sonnenschein).—Hourly Readings, 1884, part 1, January to March.—The Auk, October, vol. iii., No. 4 (New York).—Journal of Physiology, vol. vii., Nos. 5 and 6 (Cambridge).—Notes from the Leyden Museum, Nos. 1 to 4, 1886 (Brill, Leyden).—Observations Nouvelles sur le Tufeau de Cipley: A. Rutot and E. van den Broeck (Liège).—Proceedings of the Academy of Natural Sciences of Philadelphia, April to September 1886 (Philadelphia).—The Washoe Rocks: G. F. Becker.—On the Origin of Agriculture: H. Ling Roth (Harrison).

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